



BULLETIN  
OF  
ENTOMOLOGICAL RESEARCH

ISSUED BY THE IMPERIAL  
BUREAU OF ENTOMOLOGY.

EDITOR: THE DIRECTOR.

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VOL. X.

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LONDON:

1919-1920.





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# E R R A T A .

Page	20, line 42, for Sleep	read	Sleeping
"	35, " 8, " Ward	"	world
"	135, fig. 1, " ame	"	same
"	140, " 1, " <i>Dicranotropis</i>	"	<i>Delphacodes</i>
"	147, line 34, " <i>Rhynchophorus</i>	"	<i>Rhynchophorus</i>
"	151, " 12, " <i>Cyclas</i>	"	<i>Cylas</i>
"	183, " 5, " of facies	"	facies of
"	200, " 11, " n	"	in
"	253, " 35, " perpicillaris	"	perspicillaris
"	321, " 5, " V	"	M
"	465, " 42, " Jawaera	"	Goldberg

Page	64, line 15, for "6 mm."	read	"0.6 mm."
"	66, " 29, Transpose "8-9 hairs" and "5-7 hairs"		
"	69, fig. 7, The upper enlarged pecten spine should bear no secondary spines.		
"	161, line 7, For "Circum-ocular"	read	"Post-ocular"
"	" " 28, "	"	"
"	" " 29, " "Posterior"	"	"Median"
"	" " 31, " "Anterior"	"	"Lower anterior"
"	" " 32, " "Superior"	"	"Upper anterior"
"	" " 33, " "Antero-inferior"	"	"Lower posterior"
"	" " 34, " "Postero-inferior"	"	"Upper posterior"
"	164, " 36, After "these setae" insert "(previously referred to as the inner lateral row.—Bull. Ent. Res. x, p. 59.)"		
"	" " 41, After "these setae" insert "(previously referred to as the outer lateral row.—Bull. Ent. Res. x, p. 59.)"		
"	167, " 19, For "seta single"	read	"seta; single"
"	" " 30, " "(P)"	"	"(P <sup>1</sup> )"



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VOL. X.

1919.

A NEW AUSTRALIAN SPECIES OF *RIOXA*, WITH A REMARKABLE LIFE-HABIT (DIPT. ; TRYPANEIDAE).

By Prof. M. BEZZI,  
*Turin, Italy.*

Dr. Guy A. K. Marshall has recently submitted to me a Trypaneid, discovered in Northern Australia by Mr. G. F. Hill. The fly is said to have been bred from larvae having habits very different from those of the related members of the family ; and being moreover interesting from a morphological and biogeographical standpoint. it forms the object of the present note.

The Oriental species of CERATITINAE with 6 bristles on the scutellum, with a complete thoracic chaetotaxy, with a bristly third longitudinal vein, with a not wavy second longitudinal vein, and with a wing-pattern consisting of an extended brown patch with hyaline spots and hyaline indentations, have been ascribed by me\* to the two genera *Diarrhagma* and *Rioxa*. While the first of these genera is less numerous and is well characterised by the form of the head, the second contains heterogeneous elements, which have been divided by me into three groups. Following on this, Prof. Hendel† erected the new genus *Hexacinia* for the peculiar group of *stellata*, Macq., and divided the remaining species into the genera *Rioxa* (with a pectinate arista) and *Rioxoptilona* (with a plumose arista). But this last distinction seems to be a premature one, as it is impossible to draw a sharp line of separation between the species in which the arista is plumose on the upper side alone, and those in which it is plumose on both sides.

I have before me two species of Australian TRYPANEIDAE which are referable to the genus *Rioxa*, s.l. ; they closely resemble one another both in body coloration and wing markings, but may be distinguished as follows :—

- 1(2). Two upper and two lower pairs of orbital bristles present : arista regularly pilose, with some short hairs only on the under side ; mesonotum and scutellum without dark spots, the latter with the middle pair of bristles weaker than the others ; discoidal cell with two hyaline spots, which are confluent with the hyaline indentations of the hind border .

*musae*, Froggatt

\* Mem. Ind. Mus., Calcutta, 1913, iii, pp. 53-175, pl. viii x (vide pp. 108 and 111

† Wien. Ent. Zeit., 1914, xxxiii, pp. 73-98 (vide pp. 78 and 82).



- 2(1). Only a single upper and a single lower pair of orbitals; arista pilose on both sides and in the male with a tuft-like pilosity at the end; mesonotum in front of the scutellum with two blackish spots, which are extended over the scutellum itself; middle scutellar bristles as strong as the others; discoidal cell with but one isolated hyaline spot .. *termitoxena*, sp. n.

***Rioxa musae*, Froggatt, 1899.**

*Trypeta musae*, Froggatt, Agric. Gaz. N.S.W., Sydney, 1899, x, p. 501, pl. ii, figs. 1-3; id., "Austral. Insects," Sydney, 1908, p. 308; id., Report on Fruit-fly and other Pests in various Countries, 1907-8, Dept. Agric. N.S.W., 1908, p. 113, pl. vii, figs. 1-3.

*Rioxa (Trypeta) musae*, Froggatt, Proc. Linn. Soc. N.S.W., 1911, xxxv (1910), p. 872.

*Rioxa musae*, Bezzi, Mem. Ind. Mus. 1913, iii, pp. 76 and 114.

The present species was originally obtained from bananas brought to Australia from the New Hebrides; but it has been found subsequently breeding in both cultivated and native fruits in Queensland and New South Wales.

**2. *Rioxa termitoxena* sp. nov. (fig. 1).**

Differing from all the other known species in having only a pair of upper orbital bristles, and very distinct on account of the peculiar arista of the male.

♂ ♀. Length of body, 6·5-7 mm.; of the ovipositor, 1·5 mm.; of the wing, 7-7·5 mm.

Head (fig. 1, A) entirely reddish-yellow; occiput quite unspotted and shining, chiefly near the borders; it is paler on the sides beneath, and the lower swellings are not developed. Frons opaque, with the middle stripe more dark reddish (sometimes brownish on the fore half in the female), with more yellowish sides and with a black ocellar spot; it is clothed with rather dense, short and equal, black hairs; lunula yellowish. Face shallowly but distinctly concave above the rather prominent mouth-border; the broad keel between the antennal grooves is flat; cheeks very narrow, linear, whitish; jowls broader than the third antennal joint, unspotted.



Fig. 1. *Rioxa termitoxena*, sp. n.

a, head of male; b, wing of fully coloured female.

Eyes rather broad, but with the vertical diameter longer than the horizontal one. Antennae inserted near the middle of the eyes, shorter than the face, and entirely reddish; first joint very short, with black hairs at the sides; second joint short and globular, with short black hairs; third joint about twice as long as the first two joints together, almost bare, rounded at the end, only slightly concave above; arista with rather long and scattered hairs from the base to the end on the upper side, and on the apical half alone beneath; in the male the terminal hairs of the

arista are closer together on both sides, forming thus a kind of apical tuft, which is not clearly indicated in the female. Palpi broad, yellowish, reddish at the outer border, with yellowish hairs and some black bristles; proboscis dirty yellowish, with pale hairs; the hairs of the lower part of the head are likewise pale yellowish. All the cephalic bristles are black, those of the occipital border being numerous and pointed; the postvertical are long; outer vertical half as long as the inner one; no ocellar; only a single superior orbital,\* the basal one; only a single inferior orbital, the apical one, which is placed very near the antennae, and is rather weak and short; genal bristle well developed, black.

Thorax on the back entirely reddish and rather shining, the very short pubescence black and the whitish dust very sparse; the humeri, the sides above the notopleural line, and a broad postsutural stripe above the root of wings, are of a more yellowish colour, but not sharply defined; along the dorsocentral lines there is sometimes in fully coloured specimens a brownish, ill-defined longitudinal stripe; the two blackish spots in front of the scutellum are rounded and lie between the praescutellar and inner pair of the posterior supra-alar bristles, not extending in front beyond the praescutellar bristles. The pleurae are entirely reddish and shining, quite unspotted, even the hypopleural spots being not paler than the surrounding parts; the short hairs are mainly black. Scutellum triangular and of rather large size; it is flattened above, with well developed lateral keels; it is entirely yellowish, but on each side there is a triangular blackish or brownish spot in contact with that at hind border of the mesonotum; it is clothed on the sides with short black hairs, and bears six equally strong, black bristles, even those of the middle pair being as strong as the others, and those of the apical pair being parallel or diverging. Post-scutellum and mesophragma shining black (in fully coloured specimens), with a narrow, reddish, middle longitudinal stripe. Thoracic chaetotaxy complete; all the bristles are black, even the scapular ones, the middle pair of which is as strong as the lateral ones and has its bristles rather distant; praesutural bristles rather weak and short; dorsocentral bristles placed much behind, about on a level with the praescutellar ones; one strong mesopleural bristle, and 2-3 more weak ones below it; pteropleural bristle as strong as the sternopleural one. Squamulae and halteres whitish, the former with white hairs at the border.

Abdomen elongate, slightly constricted at base, and about as broad as the thorax at the end of the second segment; it is shining reddish, with broad, shining black bands at base of segments 3-5, the bands being in the female broadly interrupted in the middle, while in the male they are entire or nearly so, the last segment being entirely black; the hind borders of segments 2-5 are pale yellowish with whitish dust, thus contrasting strikingly with the black basal bands. Male genitalia black, rounded, prominent below: ovipositor shining black, depressed, with the basal segment as long as the last two abdominal segments together. Venter entirely reddish-yellow, unspotted. The short abdominal pubescence is black, like the bristles at the sides and end; the two basal segments are clothed with soft, long whitish hairs at the sides.

\* In the allied genus *Ptilona* there is likewise but a single s. or., but it is the apical one. In the recently described genus *Ortaloptera*, Edwards (Trans. Zool. Soc., 1915, p. 419, pl. xxxviii, fig. 9), from New Guinea, the cephalic chaetotaxy is very like that of the present species, while that of the thorax is much more reduced.

Legs entirely and evenly reddish from the coxae to the end of the tarsi; their short pubescence is pale, but it is black on the outer side of the femora; front femora with long black hairs above, and with 3-5 black bristles below at the end; middle tibiae with two apical black spurs, and with a short row of 2-4 short and stout black bristles at the base on the hind sides; hind tibiae with a complete row.

Wings (fig. 1, B) long and broad, with a well developed costal bristle; the stigma is of usual length; the second longitudinal vein is straight; the third is bristly throughout, moderately bent backwards beyond the middle of its last portion, and parallel with the last portion of the fourth; small cross-vein below the end of the first longitudinal vein and beyond the middle of the discoidal cell; hind cross-vein long, as long as or even a little longer than its distance from the small one, reaching below the fifth vein at an obtuse angle; point of the anal cell acute and longer than the second basal cell. The base of the wing is hyaline to a little before the end of the second basal cell and to the base of the stigma; but in fully coloured specimens the second costal cell, the basal half of the first basal cell, the base of the second basal and more narrowly that of the anal cell, are pale yellowish. The stigma is entirely dark brown, without any hyaline part. The brown patch extending across the greater part of the wing is darker on the upper half, lighter on the lower, and distinctly yellowish in some parts towards the middle. At the fore border there is a single hyaline indentation of triangular shape just beyond the stigma, reaching with its point the third longitudinal vein, a little beyond the small cross-vein. The three rounded hyaline spots in the middle are as follows: one at the end of the first basal cell, before the small cross-vein; one a little before the middle of the first posterior cell, above the upper end of the hind cross-vein; and one of greater size before the end of the discoidal cell, in contact above with the fourth vein, and distant beneath from the fifth vein. At the hind border there are two hyaline indentations; a smaller one of more triangular shape in the second posterior cell, pointing with its inner corner to the upper basal angle of the same cell, without reaching it; a larger and broader one towards the middle of the third posterior cell, with its inner, broad end in contact with the fifth vein, but without entering the discoidal cell. The axillary lobe is mainly hyaline, with a brown spot at the end of the anal cell, not extending beyond the axillary vein; the alula is hyaline. The narrow extreme base of the marginal cell is hyaline, like a small elongate spot into the first basal cell, just before and above the end of the second basal cell; the whitish oblique stripe into the brown base of the third posterior cell is very striking. The indentation of the fore border and the three hyaline spots in the middle are distinctly whitish, like the inner or superior part of the broad indentation of the third posterior cell.

Type ♂ (British Museum) and an additional specimen of female sex from North Australia, Port Darwin, 14. x. 1914 (*G. F. Hill*), bred from galleries of a termite, *Mastotermes* sp., in tree-trunks; the specimens of this couple are not fully coloured, as is frequently the case with bred flies. Type ♀ (British Museum), and an additional specimen of the same sex, from same locality and same collector, 8. viii, 1913; these specimens are fully coloured, having been taken on the wing.

Macquart (*Mém. Soc. Sci. Lille*, 1855, p. 144 [124], pl. vii, fig. 7) has described *Urophora bicolor* from Adelaide (type in Bigot's Collection), which is evidently a

*Rioxa*, but differs from both the preceding species in the wing pattern. Froggatt (Australian Insects, p. 308) reports it as a *Trypeta* as follows: "A larger native species with reddish brown head and thorax; with black body; with beautifully mottled black wings having the base and sides unclouded. I have taken it on the trunks of wattle trees near Bathurst, N. S. Wales." It is probable that this species is different from that of Macquart; the habit of settling on trunks of trees is very suggestive of that of the new species here described. In his report of 1909 Froggatt has briefly compared (p. 114) this *T. bicolor* with his own species *T. musae*.

Macquart in the above-cited work (1847, p. 109 [93], pl. vi, fig. 7) has also described from Australia (coll. Bigot) *Tephritis lugubris*, which is likewise possibly a *Rioxa*, but has a very different wing pattern and body coloration.

The *Trypeta pornia* of Walker (List, 1849, p. 1039), from Port Stephenson, is also probably a species of *Rioxa*.

It would be interesting to know if the reduced cephalic chaetotaxy (by the want of the second upper orbital bristle) is a character of the true Australian species of *Rioxa*; in this case it may be considered of generic value, chiefly when supported by such a different kind of life-history as that observed for the new species *T. terminoxena*.

Of the numerous species recorded or described from New Guinea, only the following seem to belong really to *Rioxa*: *formosipennis*, Walker, 1861; *lateralis*, Kertész, 1901; *sexguttata*, De Meijere, 1913; and *seriata*, De Meijere, 1915; but they all have a wing pattern very different from that of the species here described. The other species, like *debeaufortii*, De Meijere, 1906, *nigra*, De Meijere, 1906, *insignis*, De Meijere, 1913, *nigripennis*, De Meijere, 1913, and *flava*, Edwards, 1915, seem to belong to other genera; *quadrifera*, Walker, 1861, was placed by Prof. Hendel in his new genus *Themaroïdes* in 1914.

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# AN ENQUIRY INTO THE RELATIONS OF *GLOSSINA MORSITANS* AND UNGULATE GAME, WITH SPECIAL REFERENCE TO RINDERPEST.

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In the course of a conversation in November 1917, Mr. E. Hutchins, the Chief Veterinary Officer, Uganda Protectorate, drew my attention to an outbreak of rinderpest in the Northern Province of the Protectorate, which first manifested itself in the buffalo of the Chopi Country. The disease was then rapidly spreading through the game in the *Glossina morsitans* area between Masindi Station and the Kafu River. He pointed out the excellence of the opportunity for investigating the alleged relationship between rinderpest and fly. As I had worked from May till September 1914 in the Northern Province fly belt in association with Mr. W. F. Fiske, I was in a particularly advantageous position to estimate any alteration in the fly distribution which might have occurred as a result of the epidemic. The question had a special local significance, as, should the disease prove fatal to the fly, the introduction of rinderpest among the situtunga on the Islands of Lake Victoria would simultaneously remove the reservoir and the carrier of the mammalian trypanosomes. My release from military duties was duly sanctioned in November 1917, but unfortunate circumstances over which I had no control postponed its fulfilment until April 1918. By this time the disease had almost worked itself out in the fly area, and, what is more to be regretted, the long-deferred rains had commenced throughout the district. The heart of a unique opportunity was thus lost.

The Masindi fly belt had been studied in 1914 for several months by Fiske, a highly trained entomologist with considerable experience in the scientific handling of insect pests on a large scale. His careful observations on the bionomics of the fly in this belt are of the greatest value in arriving at conclusions regarding the present problem.

There is a strong consensus of opinion among Europeans of experience in South Africa that the great rinderpest epidemic of the nineties resulted in a marked decrease in the tsetse in the fly areas through which the disease passed, amounting, in some districts at any-rate, to the immediate or eventual disappearance of the fly. The explanation of this phenomenon most generally advanced is that the fly disappeared as a direct result of the great destruction by the disease of the wild game upon which it depended for food. The fly were, in other words, starved to death.

In this paper it is proposed first to review the somewhat meagre evidence bearing on the interrelation of game, fly, and rinderpest, and to discuss the same with the aid of personal experience and observation. Then to proceed to the actual experiments which were undertaken to decide whether rinderpest blood, *per se*, is or is not destructive to *Glossina*; and, finally, to endeavour to arrive at some kind of understanding regarding the relations of fly and game and the conditions which lead to a disappearance or diminution of *Glossina*. My apology for presuming to attack so complicated a problem is that I have recently been privileged to witness the

occurrence in Uganda of a marked and independent diminution in the numbers of two of the best known species of *Glossina*, and also an outbreak of rinderpest among the game of a *morsitans* area. It is to be hoped that the observations made on the spot may be of value in throwing additional light on the bionomics of *Glossina*.

My thanks are due to His Excellency the Governor, Sir F. J. Jackson, who has throughout evinced an interest in these investigations, and has kindly given me the benefit of his wide experience of game and fly in South Africa. Also to Mr. Hutchins, C.V.O., whose valuable advice and assistance I have found of the greatest help. I am indebted also to the Administrative Officers for their assistance in obtaining food in the face of a general scarcity caused by the famine.

### Historical and General Evidence from the Literature.

As regards the disappearance of *Glossina morsitans* from various districts in Rhodesia and the Transvaal following on the rinderpest epidemic of the early nineties three explanatory theories demand special consideration :—

(1). That a fly which absorbs the blood of an animal suffering from rinderpest dies as a direct consequence. Death might be immediate, and due to poisonous by-products circulating in the blood; or it might result subsequently as a result of the development of the rinderpest organism in the tissues of the fly. Again, rinderpest blood might exert an injurious effect on reproduction.

(2). That the fly disappeared owing to loss of its normal food supply, the wild game. A special development of this theory supposes that certain species, especially buffalo, are more responsible than others.

(3). That the phenomenon had no direct connection with the rinderpest, being due to some obscure coincident cause.

With regard to rinderpest blood, *per se*, killing fly, we have reliable evidence that in certain districts no difference was observed in the numbers of the tsetse, in spite of the passage of the disease through the game of the fly belt. Sir Alfred Sharpe (1) writes that when the rinderpest visited Nyasaland, there was a noticeable decrease in the numbers of big game in some of the fly belts, especially of buffalo, "but I have never noticed that this had any effect on the *Glossina*." Val Gielgud (2) writing from N. E. Rhodesia says: "Since the almost total destruction of buffalo by rinderpest these flies have not disappeared, although, perhaps, not so numerous as formerly. Stevenson-Hamilton (3) remarks, "while there is no doubt that *G. morsitans* (?) absolutely disappeared from considerable areas during or immediately after the epidemic, we have it on reliable authority that elsewhere it was in no way affected." Sir David Bruce (4), in his evidence before the Sleeping Sickness Committee in October 1913, states that, in response to his request, Montgomery in British East Africa fed "a lot of flies on rinderpest animals and it did them no harm." I recollect sending the pupae from Mpumu to Montgomery for these experiments, the report of which I have not been able to obtain. The pupae were those of *G. palpalis*. I have, however, always understood that owing to difficulties of transport of the pupae, etc., it was found to be impossible to pronounce an opinion as to the effects of the rinderpest organism on the fly, except in as much as the blood of the sick animals was apparently not immediately fatal. Further evidence on this important point will be produced in a later section.

Regarding the second explanation, that fly disappeared because their food supply, the game, was destroyed by the rinderpest, there is considerable difference of opinion. While the majority of the observers hold that the fly are more or less intimately dependent on the game for their existence, others, and among them Stevenson-Hamilton, Sir F. J. Jackson and Neumann, point to the existence of fly areas in which, they state, game is either absent or in numbers inadequate to constitute the sole food supply for the existing tsetse.

If it were possible to discover an area in which tsetse exist year after year and from which the presence of ungulate game and their attendant carnivora could be completely excluded, we should then know that the fly could subsist entirely on baboons, monkeys, small mammals, birds and reptiles. But, so far as I can discover, no such game-free fly belt has been found. Even if such did exist, however, it would not necessarily follow that the sudden or even the gradual disappearance of the ungulates from a tsetse area rich in game would not ultimately be detrimental or even fatal to the fly. Apparently rarity of the game is a different proposition; the human standpoint may well differ from that of the fly in such matters. Thus, little is known at present regarding the length of time wild fly can exist without blood, or the relation between food supply and the production of larvae. I have kept wild captive *palpalis* alive without any food for 10 days, and it is highly probable that fly under natural conditions can exist much longer without blood. The hardiness of the fly, coupled with the local habits of such game as duiker, dikdik, warthog and bushbuck, must be borne in mind in dealing with an apparent absence of game from a fly belt.

One of the best authenticated examples of the occurrence of tsetse in a locality almost totally devoid of ungulate game is the fly belt mentioned by Stevenson-Hamilton (3) in the Nyassa district of Portuguese East Africa. His personal observations as to the rarity of the game at the time of his passage, the dry season of 1908, must be accepted as correct as coming from a careful observer and a keen hunter. It is, however, plain from his reports that big game did exist in the neighbourhood, though in very small numbers. He himself mentions a "few kudu" in the narrow strip of country between the fly belts; and Howard (5) referring to Hamilton's trip mentions one waterbuck having been shot, the presence of a few elephant, and the finding on one occasion of buffalo spoor. The party traversed the bush along a main native track, and their opportunities for studying the fauna of the belt were limited to the vicinity of this track. Howard produces evidence showing that 5 or 6 years before Hamilton's visit this district was full of big game, and it is evident from the account of Barnett's trip along the Rovuma River (6), that in 1910 both game and fly were present in fair numbers in the country immediately to the north of the belt. Reference to Howard's map of the fly distribution in Portuguese East Africa shows that in 1910 the first of the two belts was a mere focus, possibly a disappearing remnant of the greater numbers seen by Hamilton. Hamilton describes the fly as in "swarms" and "extremely troublesome, often biting ourselves and our natives after sundown." It is, indeed, usual to find references to areas where game is rare couched in similar terms. But it is possible, indeed probable, that under these circumstances, their number and persistence testify rather to the desperate vigilance of flies assembled from a large



radius than to a similar prevalence throughout the belt. Hamilton notices that the fly were concentrated along the main track in the neighbourhood of camps and halting places, localities in which experience had taught the insects to expect their supply of blood. They are even reduced to so far departing from their usual habits as to bite at night time. Fiske, among other reliable observers, has drawn attention to the following propensities of *G. morsitans*. "In the Masindi fly belt, the only *morsitans* area in which I have seriously studied this fly, I have noticed that the passage of a 'safari' of porters or, better still, of a cyclist, will to a very large extent clear a road of its waiting tsetse, with the result that an observer following on a short time afterwards may find few or no fly until arriving near the edge of the belt. The swarm of *morsitans* which sweeps along in the wake and round the person of a cyclist passing through a fly belt gives him an entirely false impression as to the true prevalence of the fly." I labour this point because the fallacy of inferring from the numbers of tsetse buzzing about the observer a similar infestation of the belt as a whole is by no means rare.

A consideration of all these points reveals an alternative or, at any rate, a modified explanation of the facts noted. Game was very rare in the part of the belt traversed, and the local fly were probably hard-pressed for mammalian blood. Hence their voracity and persistence, and their concentration at spots where, in addition to their natural liking for the edge of a path, they could best satisfy their hunger. Further, it being the dry season, these fly would tend to concentrate in certain favoured localities (cf. *infra*). Probably game such as duiker, oribi and warthog existed scattered throughout the belt; also a few large game remained. The existence of fly in the country immediately to the north of this belt in 1910 may mean that, in consequence of a migration of the game, the tsetse were gradually shifting northward to merge with the Rovuma belt, in a richer game country.

Hamilton himself realises the danger of dogmatism on so important a question as the result of a single trip; but none the less, he has laid considerable stress on the apparent independence of these fly. His facts show that, in certain localities, *morsitans* can temporarily adapt itself to the almost total absence of ungulate game. Natives and their domestic animals, monkeys, birds, reptiles, and probably hyaenas, were available to the fly in the present instance. Whether the survival under these gameless conditions is permanent, or merely pending an alteration of range, is at present an unsolved question.

In the majority of the tsetse areas of British East Africa it appears from the writings of Jackson, Neumann, and others (7) that game occurs only in very small quantities. Neumann (8), describing the country south of the Athi River above its junction with the Tsavo, writes: "Here are great stretches of uninhabited bush country with a perennial river running through it, and hardly any animals, though plenty of birds and of 'fly,' Tsetse." But in his description of this scanty game he says "a very few waterbuck at intervals, an occasional lesser kudu or two, a little lot of impala, sometimes at one particular point, and rarely an odd bushbuck, are all that are seen, without counting the diminutive paa, and now and again a rhino, giraffe or hippo spoor."

Here we have a fairly comprehensive menu, however barren the district may seem to the hungry hunter; yet it is just "sufficiently" restricted to render the fly

appreciatively attentive to a human visitor. Such conditions are, I imagine, fairly typical of many of the so-called gameless fly belts. A less keen observer than Neumann might very well have overlooked some of the species mentioned.

Competent observers such as Woosnam, Yorke, Bevan, Lloyd, Shircore, etc., are unanimous that they know of no instance where *morsitans* occurs in the total absence of big game (9).

It is possible, however, that the tsetse of a belt are adapted to the special conditions of that belt as regards the distribution, species and numbers of the game. In a district where buffalo and other big animals are numerous these will be most easily accessible to the fly, especially in the long grass season. The tsetse will therefore learn to depend on these bigger animals. In another belt the regular food supply will be the smaller antelopes, baboons, warthog and carnivores. Any cataclysmic alteration in the game distribution of a belt, especially if it occurred at the critical time when the grass is up, might well be seriously detrimental to the tsetse, whereas a more gradual alteration would give time for a varying degree of adjustment to the new conditions.

*G. palpalis* on the islands of Lake Victoria often shows a deliberate preference for reptilian over mammalian blood. In other regions, such as the neighbourhood of the crater lakes near Lake Albert Edward, crocodiles are absent and *Varanus* rare, and the *palpalis* are plainly dependent on the numerous hippo and other game animals. Evidence of a similar independence in *G. morsitans* is wanting. The smaller mammals in *morsitans* country, though doubtless occasionally fed upon by the fly, will, by their habits, be difficult to find, especially when the grass is up.

I have found *Varanus* in the middle of the Masindi *morsitans* belt, though there were no fly around at the time. The extraordinary partiality of *G. palpalis* for this saurian suggests the possibility of the more fastidious *morsitans* feeding upon it on occasion, and this fly has been found to contain non-mammalian blood in nature. In the present state of our knowledge, however, these creatures must be looked upon as accessory sources of food, and it is the general opinion of experts that mammalian blood is necessary at any rate for the propagation of the fly (Lloyd).

My own experience of *morsitans*, apart from the Masindi belt which will be dealt with later on, is founded on visits to the following belts in "German" East Africa under active service conditions:—(1) The great fly belt on the Tabora and Mwanza road; (2) the Buzinza area to the west of Mwanza; (3) the Namirembe-Biharamulo belt, possibly continuous with (2), around the south-west corner of Victoria Nyanza; (4) between Ikoma and the Mara River and E. towards Olgoss; (5) the area along the Kagera River, near the south frontier of Uganda.

In all these belts game is common, excepting the first, in which I spent about 11 days at Shinyanga, well within the fly zone, at a time when game, excepting dikdik, was rare, having recently migrated in search of water. In none of the above belts was buffalo found within many miles of my camps. The fauna observed in each case respectively comprised:—(1) Zebra, Thomson's gazelle, giraffe, duiker, dikdik (plentiful), hyaena, roan, impala, carnivores; (2) sable, topi, reedbuck, kudu (few), hyaena, duiker, roan, impala, zebra, dikdik, giraffe, carnivores; (3) the same as in (2), plus rhino and dikdik (very common); (4) Thomson's and Grant's gazelles.

oribi, rhino, hartebeest, topi, roan, wildebeest, duiker, zebra, impala, dikdik, carnivores; (5) roan, impala, oribi, duiker, eland, zebra, topi, impala, wild dog and other carnivores.

In these belts fly persisted throughout the dry season and the burning of the grass. They appeared much addicted to the neighbourhood of paths, and, in places where motor transport was employed, illustrated to a remarkable degree the "following" propensity of *morsitans*. On the whole, the fly were not particularly troublesome, except in connection with motor vehicles, around which they collected literally in swarms.

In the North-East Transvaal Stevenson-Hamilton (3) states that the fly completely disappeared immediately after or during the rinderpest of 1896-1897, and has never come back. Apparently it disappeared also from the adjoining Portuguese territory. As regards the effects of the disease on the game he writes, "after the rinderpest it was found that the last of the eland in the N. E. Transvaal had disappeared, and that the buffalo were reduced to a herd of about 20, which remained in the densest part of the Sabi Bush in the heart of the former fly country. A small number of kudu and bushbuck survived in the same locality. Impala, wildebeest, and other species, native to the district, appeared much as formerly." In this district the rinderpest arrived among the game at the season of the long grass.

Gibbons (10) writes of North Barotseland: "I may mention that between 1896 and 1897 the tsetse has disappeared in many districts where it was previously rampant, and is so decimated in others as to be scarcely perceptible." Again Jack (11) speaking of the Lomagundi district of Southern Rhodesia says: "It would seem that the fly in this part survived the rinderpest in very small numbers in scattered localities, failed to increase to any extent, but persisted until recent years, although on the verge of extermination." Hamilton contends that "in the absence of any other destructive cause, the fact that even a few buffalo, kudu, and bushbuck survived, supposing these animals to provide the favourite food of the *morsitans*, must surely have induced a partial survival of the latter, a nucleus which in the course of years would have increased with the increasing herds."

From a consideration of the above evidence the following points emerge :—

(1). That there is no known instance of the prolonged existence of *G. morsitans* in an area where game is entirely and permanently absent.

(2). That the fly is generally found associated with game in considerable numbers and variety. It may, however, occur in localities where wild ungulates are apparently scarce. Under these circumstances the tsetse are probably pressed for food and their appreciation of the human visitor is apt to give their exasperated victim an exaggerated impression of the degree of infestation of the belt as a whole. This impression will be enhanced by the "following" propensities of the fly.

(3). That during the rinderpest epidemic of the nineties the tsetse of South Africa were affected differently in different localities. The fly were either (a) apparently unaffected; or (b) markedly reduced in numbers, temporarily or permanently; or (c) reduced to the point of ultimate extinction. Generally, however, the passage of the rinderpest throughout the fly country was marked by a great diminution in the numbers of the tsetse.

(4). That the rinderpest affected some species of game very severely and left others almost untouched, with the result that a large number of animals escaped destruction.



(5) That the theory regarding buffalo as essential to the subsistence of the fly is untenable. It is possible that the fly of an area where buffalo are very numerous may resort to this species as its chief food supply. This would, however, apply equally to whichever of the larger ungulates predominated, and probably depends on the ease with which these big animals are accessible to the fly, especially at the season when the grass is high. The arrival of the rinderpest at this season would enhance its effect on the fly through its food supply.

(6) That much of our information regarding the relations of game and tsetse is based on superficial observations by untrained observers on isolated occasions. In such circumstances the persistence of small isolated foci may easily be overlooked.

### Description of the Masindi Fly Country.

The Masindi fly area comprises an extent of bush country in which tsetse has always been fairly numerous and evenly distributed in the wet season. In the dry season, after the annual grass fires, a diminution in number has been noticed both by Fiske and by the native inhabitants of the belt. During this dry season Fiske says that the fly appear to be concentrate in certain localities, which show special characteristics and resemble Shircore's "primary centres" (12). Game is fairly plentiful throughout the fly belt. The main motor road from Masindi Port to Butiaba traverses the belt, which towards the River Kafu is limited by open plains swarming with kob and reedbuck. A few small villages are scattered about here and there. The fly scrub itself consists of scattered small trees and bushes rising above the coarse grass, which grows in tufts and, in July and August, reaches a height of 6 or 7 feet. Long low ridges are separated by valleys of varying extent, sometimes narrow and thickly covered with bush, sometimes wider with thinner bush or open stretches of shorter grass. In the rainy season these valleys hold swamps. In the dry season there are two types of waterhole found in the belt:—

(1) Muddy depressions or holes containing filthy water and pitted with game tracks. These holes are occasionally found on the ridges, but more generally lie along the bottoms of the valleys. This type of waterhole dries up slowly, and the gaping cracks in the sun-baked bottom will absorb many showers without leaving any standing water on the surface.

(2) Punched out holes or ponds often of clear water, situated on the ridges. Of these holes Fiske says "They fill and overflow during the rains and usually dry quickly following their cessation." Also, and this is probably important, they are replenished by any chance shower of rain. Such a waterhole is a feature of Fiske's "foci," in which the fly concentrate during the dry season. Other characters of these foci are freedom from bush, and shorter finer grass; they are surrounded by bush which is often unusually thick. Game is also always present. Fiske assumes, as a result of his work in the belt, that *morsitans* finds particularly favourable conditions for breeding within these foci, at all events during the least favourable season of the year, and that it disperses from them freely, especially during the wet season.

No fly are found in the open plains about the Kafu except such as may follow passengers along the roads. As regards pupae, I have found these in fair numbers in the crevices of ant-hills and under fallen tree-trunks. Fiske is of opinion that



throughout the belt, when the grass is up, large numbers of pupae are deposited indiscriminately in the grass-tufts, and that the crevices and tree-trunks are more especially a resort for the fly, short-grass season. He finds that the fly breeds less freely during the dry season; an observation also made by Lloyd in Northern Rhodesia. During my stay in the belt in 1914, in May and June, fly were fairly numerous throughout the area, especially along the various roads traversing the belt. It was practically impossible to bring a dog along the Nakasongola-Masindi road where this traverses the fly scrub without it becoming infected with trypanosomes. Cycling and even marching along this and the other roads was unpleasant to a degree on account of *morsitans*; whilst trekking through the bush in search of game the fly were in evidence, and often a nuisance.

### Observations in the Masindi Belt during April and May, 1918.

On my arrival in the fly area in April 1918, I was at once struck by the marked decrease in the numbers of the fly met with. I visited all the localities seen in 1914, including some of Fiske's foci, and am confident, from a comparison with the number of flies caught in May 1914, that there has been a very marked reduction. I had with me fly boys who had previously worked with me in this belt, and they were unanimous that fly were much diminished everywhere and often unobtainable where they were formerly fairly abundant. On only one occasion did I find fly at all numerous, and this was in the immediate wake of a large herd of elephant at a waterhole. The fly had disappeared from this spot the next morning. Cycling along the main motor road was no longer a penance, and on trekking about from point to point in what used to be the most thickly infested parts of the belt the fly were few and far between. I found no evidence of a corresponding local increase in any part of the belt north of the Kafu River. The grass was growing rapidly, though, perhaps, not so long as it was in places during my visit in May 1914. There is reliable evidence that fly were still worrying cyclists along the motor road throughout the earlier part of 1917. In May of that year two independent and reliable observers report that the fly were numerous. In November 1917 Mr. Bain, the District Engineer working in the Masindi district, tells me that he visited the fly belt along the main road and was struck by the apparent absence of tsetse.

A considerable number of buffalo were killed by the rinderpest in this fly area. Bushbuck, warthog and duiker also suffered severely, waterbuck and hartebeest being little affected. The kob and reedbuck on the Kafu plains also died in considerable numbers. A certain number of buffalo survived the epidemic.

I next visited the Bugungu fly country, through which the disease had spread from Chopi. These parts I had visited in August and September 1914. Owing to the famine of 1918 it was impossible to "safari" through this big area. I therefore went by sailing boat along the north-east shore of Albert and up the Victoria Nile to Fajao, camping at intervals along the bank and striking inland to visit the scenes of my former tour. As a direct result of the epidemic, the buffalo moved south along the Bugungu plain to the point where the escarpment joins the lake near the outfall of the Waki River. They left a train of dead along their course, a striking feature of these bodies being that most of the skins remained intact and the bones were not generally pulled about by carnivores. Bodies of kob and warthog were also found.

Throughout the parts visited, *G. palpalis* was still found where it occurred in 1914, and in large numbers. On several occasions I found it abundant, as testified by actual catching in the bush surrounding the dried-up remains of a buffalo, the sick animals almost always making for water. *G. morsitans* was found in various parts of the area, but here the reduction in numbers was much less marked than in the Masindi Port belt. In one place, however, I found (and caught) considerable numbers, and here the fresh tracks of a herd of some 20-30 buffalo were observed. In the Bugungu region numbers of waterbuck have survived, and elephant are common and frequent visitors. Buffalo have survived in small numbers out of the numerous herds which existed throughout the district before the rinderpest. Kob and reedbuck also occur; bushbuck and pig used to be common, but I saw none alive during my visit.

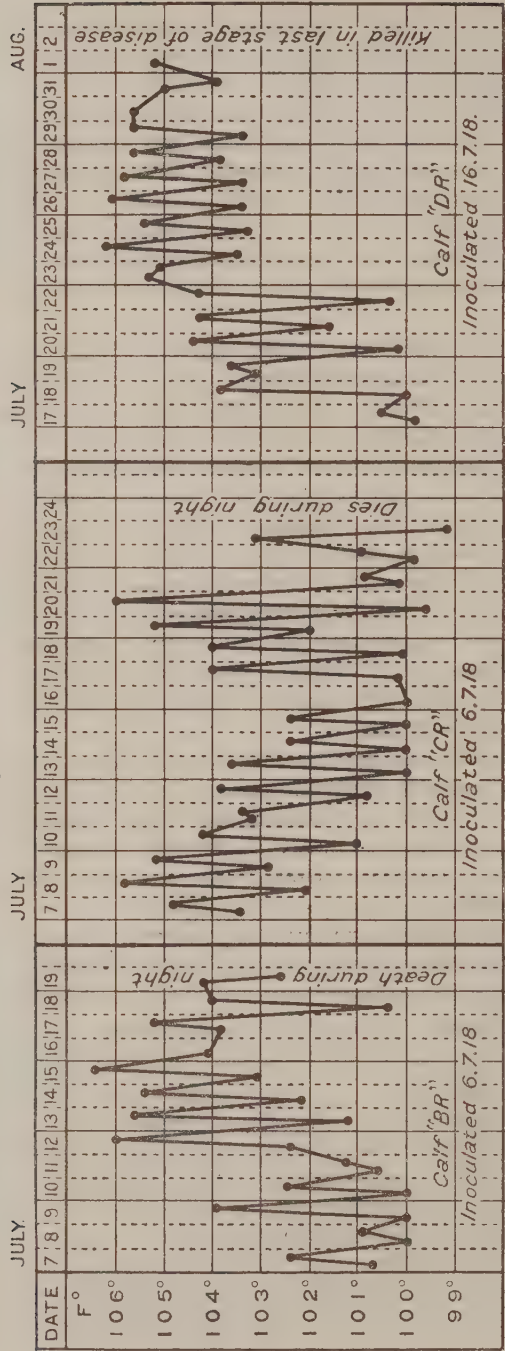
In order to ascertain whether the fly had migrated southwards across the Kafu River with the buffalo, I sent two reliable fly boys for a three weeks' trip through the Buruli district. In 1914 Fiske and I found fly exceedingly rare in this area, but its existence was known. The boys obtained *G. morsitans* from several localities, sparsely distributed. At one spot, some 15 miles south of the Kafu, they described the fly as numerous. A single specimen of *G. pallidipes* was taken. It appears, therefore, that fly are more numerous in Northern Buruli than they were in 1914. There is no known focus of *morsitans* in the south from which these fly could have spread. Whether this increase is a direct result of the rinderpest, it is difficult to say. The buffalo are in the habit of visiting and crossing the Kafu in normal times, and it is almost certain that, in their panic of the rinderpest, considerable numbers must have trekked south into Buganda. The disease has at the time of writing reached within 40 miles of Kampala, and the main agent in this spread is beyond doubt the game, especially buffalo.

To sum up, there has been a marked diminution in the numbers of *G. morsitans* in the Masindi fly belt, coinciding with the passage of the rinderpest through the game of the district. The fly is not exterminated, but the reduction in numbers is much more marked than that which ordinarily results from the annual hot season. In Bugungu the reduction, if such has occurred, is less apparent. There is no apparent reduction in the numbers of *G. palpalis* in either district.

In both areas considerable quantities of waterbuck have lived through the epidemic. Buffalo have also survived in some numbers, though, on the Bugungu plains especially, the number of dried carcasses testifies to a heavy death roll.

#### **Experimental Investigation of Effect of Rinderpest Blood on Glossina.**

It was found impossible to obtain *G. morsitans* in sufficient numbers to carry out feeding experiments in the actual belt. I was therefore obliged to utilise *G. palpalis*, and, to avoid all danger of introducing the rinderpest into the populous districts around Entebbe and Kampala, it was decided to select a suitable island on Lake Victoria for the scene of the experiments. Nsazi Island some 15 miles south-east of Entebbe was chosen, and Mr. Hutchins supplied me with rinderpest blood from Singo, where immunity inoculations were in progress. He most kindly performed the inoculations and twice came out to the island to assist me with his advice regarding the progress and diagnosis of the disease in the calves. The temperature charts will be found below. Calf B. R. was seen by Mr. Hutchins, who confirmed



the diagnosis. The other two rinderpest animals, calves C. R. and D. R., showed typical symptoms, both before and after death. The following animals were used in these experiments :—

*Calf A*—not immunised against and not infected with rinderpest. Kept isolated from rinderpest animals on the island. Used for control feeding.

*Calf B. R.*—inoculated with citrated rinderpest blood on 6.vii.1918, 34 hours after removal from sick animal. Died with typical symptoms of rinderpest on 19.vii.1918.

*Calf C. R.*—inoculated on 6.vii.1918 with 20 c.c. of pooled citrated blood from three rinderpest animals, 30 hours after removal from body; this apparently failed to infect. Stalled in closest contact with *Calf B. R.* and died on 24.vii.1918 with symptoms of rinderpest. Post mortem showed mouth ulcers and acute inflammatory exudation into lower bowel.

*Calf D. R.* inoculated on 16.vii.1918 with pooled citrated blood from three cases of rinderpest, 24 hours after removal from body. Killed on 1.viii.1918 after showing typical rinderpest symptoms for some days, confirmed by post mortem examination.

*Sheep E, F, G, H, and K*—healthy animals kept for control feedings, and stalled at a distance from the rinderpest animals. None of these sheep showed any signs of illness.

*Calf A*—developed symptoms strongly suggestive of “*amakebe*,” i.e., great enlargement of lymphatic glands, transient diarrhoea, and anaemia. The blood proved negative to *Piroplasma* a few days before it was killed. The animal also showed extensive skin lesions, which Mr. V. F. Richardson, to whom I described the case, said were very suggestive of a blastomycotic infection. This animal was killed on my returning to the mainland, together with all the other animals then alive. There was no sign of any inflammation of the gut. The animal may, therefore, be considered as clean as regards rinderpest, and was rapidly recovering condition when it was killed.

On 17th and 22nd July the dead flies in the experiments were entered on the day following in each case, except in Experiment 22.

It will be seen from this table that rinderpest blood exercises no apparent effect on the fly.

It was impossible to pronounce decisively regarding the effect on larva production.

A certain number of larvae were produced during the course of the experiments, of which a number were prematurely aborted. No difference in this respect was noted between flies fed on rinderpest blood and those fed on clean animals.

### Meteorological Conditions in the Masindi Belt in 1918 and Previous Years.

Masindi is 29 miles along the main motor road to Butiabwa from Masindi Port. The fly belt extends up to about 12 miles from Masindi Port.

The following table shows the monthly rainfall for the years 1914–17, and January–May 1918. In regard to these figures, which were taken at Masindi Station, it must be recollected that the actual fly scrub receives less rain per annum than Masindi, which is surrounded by high hills. The right-hand figures in each annual



column of the table represent the rainfall taken some 15 miles north-west of Masindi in a still more hilly and much forested district with a proportionally heavier rainfall. In consequence of the exceptional drought in November 1917 the grass fires of the 1917 hot season began early in December, somewhat sooner than usual. A severe famine prevailed during the early months of 1918 throughout the whole Province of Bunyoro.

*Masindi Area Rainfall.*

	1914.		1915.		1916.		1917.		1918.	
	A.	B.	A.	B.	A.	B.	A.	B.	A.	B.
January	2.31	1.00	1.53	0.84	0.00	0.00	4.82	3.79	0.00	0.00
February	1.45	2.97	2.99	1.14	3.96	4.71	5.59	7.28	0.00	0.42
March	4.17	4.61	6.97	3.93	5.12	5.01	1.23	1.71	2.66	4.75
April	3.80	3.80	4.37	6.03	7.48	7.16	4.96	6.87	10.06	
May	6.75	8.25	6.45	8.10	9.93	5.76	8.65	7.09		
June	4.36	7.09	3.88	4.54	2.44	4.56	7.04	4.45		
July	3.46	6.70	2.57	2.00	0.56	0.88	1.49	1.33		
August	3.68	3.82	2.05	2.26	5.20	5.52	3.38	5.00		
September	7.40	6.74	6.14	6.75	5.94	10.79	11.85	6.80		
October	6.00	5.10	6.89	9.39	8.29	10.58	7.51	7.75		
November	9.07	9.82	3.58	6.00	3.80	4.50	0.80	1.46		
December	1.33	0.78	2.92	2.50	2.19	2.00	4.17	1.99		

The column A shows the rainfall at Masindi, and B the rainfall at a spot 15 miles north-west of Masindi.

In normal years the grass fires begin at the end of December and extend through January into February. The big rains begin in March. The grass is burnt somewhat irregularly, but the result of the hot season and its fires is that most of the grass in the fly belt is burnt to the ground and the smaller shrubs severely scorched. Growing trees are hardly affected; fallen trunks are more or less destroyed, often smouldering for days. The grass grows rapidly after the onset of the rains, and in July and August has reached a height of 6-8 feet in many parts.

### Conclusions.

Of the game species available to the fly in the Masindi belt, warthog, bushbuck, duiker and carnivores are undoubtedly the most important, considering the belt as a whole. Elephant and buffalo come and go; hartebeest and waterbuck are local in their range, especially the latter; the kob and reedbuck of the open plains sometimes encroach upon the edge of the fly scrub, but are probably seldom bitten; and there are, I believe, no dikdik in this area.

In Bugungu the conditions are similar, except that elephant and waterbuck are much more numerous, and hippo from the Nile and Lake Albert roam far inland.

Fiske (13), discussing the food supply of the Masindi belt fly, applies the principle, established almost beyond doubt for *G. palpalis*, that the percentage of females among the active flies caught is a direct index to the abundance of food animals. He writes that "The flies in this belt are well fed during April, May, and a portion of June, but during the latter part of June and in July begin to find difficulty in obtaining sufficient food. The percentage of females caught rises, and coincidentally

the flies become more persistent in their desire to feed upon man. This change in their behaviour is also coincident with the coming to maturity of the grass, which in early May would not suffice to hide even a duiker, but by the middle of June would completely conceal bushbuck and pig in most localities, and larger animals in some."

Now the rinderpest commenced in Chopi a few miles to the north of the scene of Fiske's and my work in 1914. The disease spread rapidly through the buffalo, which, as usual, migrated, some going towards the Bugungu escarpment, some making south for the River Kafu and Buganda. Right through the long-grass season the game was dying in numbers throughout the fly area. The elephant, which descend towards the River Kafu in the rains, were still in the thick elephant-grass country of the Chopi reserve. Bushbuck and warthog were dying in numbers. The food supply of the fly was thus severely reduced just at the time when food is, under ordinary conditions, most difficult to find. The drought, beginning in November, led to an early drying of the grass and commencement of the fires. Similarly the intensity and prolongation of this drought led to an unusually complete burning of the bush. The fly were thus doubly handicapped. Firstly, their food supply was diminished at the most critical season of the year; and secondly, the adverse conditions of deprivation of shelter and destruction of breeding grounds were intensified by the prolonged drought.

I consider that these phenomena afford a reasonable and probable explanation of the remarkable diminution in the numbers of tsetse in the Masindi fly belt. The Bugungu country, being uninhabited, is less subject to burning in the dry season, as these fires are started and kept up by natives.

It remains now to be seen whether the principles elucidated in connection with the Masindi *morsitans* belt are applicable to the problem of the North-East Transvaal.

In this latter district the rinderpest arrived about June in 1896, and the game were still dying fast in October, the hot season. The grass reaches its full growth in June and in some years the fires may not commence until September. I can find no data regarding the particular climatic conditions obtaining in 1896-7 in this part of the Transvaal. It is therefore impossible to say whether or not the dry season that year was unusually prolonged.

One of the two factors already discussed in dealing with the Masindi fly is, however, common to both cases, i.e., the arrival of the disease in the district at the season of the year when the grass is up and game most difficult to find.

Regarding the complete and permanent disappearance of the tsetse from a large strip of country, described by Hamilton as coincident with the passage of the rinderpest, it would appear from his paper that he arrived in the district in 1902, some five years after the epidemic. From the date of his arrival he is satisfied that no recurrence of the tsetse in their former haunts has taken place. That the fly disappeared completely in the season I think improbable.

The truth probably is that, in consequence of the combination of adverse conditions afforded by the arrival of the disease in the cold weather, together with a prolonged dry season with consequent more complete burning of the grass, the fly were very markedly reduced between June 1896 and April 1897. Small isolated foci probably

persisted which, for reasons undetermined at present, instead of increasing, diminished to the point of absolute disappearance before Hamilton's arrival in 1902.

This explanation is compatible also with the apparent irregularity in the effects of the disease on fly distribution in different areas. To exert its maximum effect the epidemic should arrive during the season when the grass is long. In its passage through the country it may reach certain fly belts when the grass is yet short and the game easy to see. In such case the effect on the fly might be less severely felt. The tsetse would be better able to follow the migratory movements of the susceptible game, and to locate the whereabouts of such relatively immune species as waterbuck, impala, and hartebeest, whose distribution is local.

The practical outcome of these observations is that *morsitans* should be attacked during the dry season of the year, when natural conditions are most unfavourable to it. The two main indications are:—(1) Destruction of the primary centres or foci referred to by Shircore and Fiske by filling in or drainage of the water supply; destruction of game in the vicinity, and careful burning of the grass at the most suitable time. (2) Careful control of bush burning so as to obtain the maximum effect of the fire; indiscriminate and patchy burning by natives to be stopped, and the fires started and maintained in a systematic manner so as to ensure universal burning of the grass.

An observation made by Dr. Sander (14) in German East Africa in a pamphlet on tsetse in 1905 is of interest in this connection. He says that both Europeans and natives attribute the increase and spread of tsetse in the area between Tanga and Kilimanjaro to the cessation of annual grass fires. The game in this area had diminished very greatly.

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## NOTES ON THE MORE IMPORTANT INSECTS IN SUGAR-CANE PLANTATIONS IN FIJI.

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The writer of the following notes has been engaged on entomological investigations in Fiji, Australia and Hawaii since 1914; the work has been entirely confined to the pests of sugar-cane and has been carried on mainly in the first-mentioned country, where insect depredations are very serious and materially reduce the profits on a considerable number of plantations. The investigation of these Fijian cane pests open up a field that is practically new, and so the work will probably continue for some considerable time. The length of the period that is likely to elapse before the publication of final results is such that it seems desirable to place on record a few of the main points in the life-histories of the more important insects of the sugar-cane plantations of that country, and so the writer has compiled these notes containing summaries of their life-histories in so far as they are at present known to him.

### *The Sugar-cane Industry in Fiji.*

The six sugar-cane mills operating in the Fiji Islands are all modern well-equipped factories handling large quantities of cane. Four of the mills are the property of the Colonial Sugar Refining Co. Ltd. (Fiji & New Zealand), the remaining two being owned by other interests. The writer is not conversant with the conditions at the latter mills, and so his remarks on the status of the various insects are based mainly on observations made in the districts supplying the mills of the Colonial Sugar Refining Company, namely, Lautoka, Rarawai, Nausori and Labasa, the first three being situated on the island of Viti Levu, and the fourth on the island of Vanua Levu. Nausori is the only one situated on a windward coast, and is generally spoken of as a "wet" mill on account of the rainfall there being so much heavier than at the other three, which are usually referred to as "dry." The use of the term "dry" does not mean that any of the mills so designated suffer from an insufficient rainfall; on the contrary it is generally ample at all the mills, and indeed in some seasons it is excessive. The average rainfalls for the eight seasons ended December 1916 are as follows:—Nausori 120 inches, Labasa 87 inches, Rarawai 82 inches and Lautoka 66 inches. Most of the rain falls during the hot season, which lasts from December to April.

In Fiji sugar-cane is grown on comparatively small isolated blocks of land, which generally form a narrow interrupted strip along the coast, or along the banks of the more important rivers, large compact areas such as exist in Hawaii and other sugar-cane countries being quite unknown. The smallness and isolation of the various cane areas is due to the fact that most of the land is quite unsuitable for

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cultivation, the interior being one mass of mountains, which not infrequently run down to within a mile of the coast line. The most profitable soil for the growth of sugar-cane is found on the alluvial flats along the banks and near the mouths of the rivers; between these cultivated river flats and the mountains there is a variable quantity of undulating land and foothills on which some cane is grown, but only a small percentage of that land can be profitably put under sugar-cane, and consequently very little cane is grown at an elevation of more than one hundred feet above sea-level.

The cultivated soils may be classified under the following headings: (1) alluvial flats, (2) red hill soils, (3) sands, (4) stiff clays and (5) "tiri" or reclaimed salt-swamps. The alluvial flats are very rich and give heavy crops of cane, while the red hill soils are deficient in humus and give a light but sweet yield; the sands give good sweet crops in wet years, but in dry seasons the results are frequently poor. The stiff clays are difficult to work, and consequently they rarely give good returns. The reclaimed salt-swamps vary greatly in physical properties, but are all alike in giving only a medium or poor yield of cane.

The season for replanting fields that have been under fallow is in the early months of the year, while the harvesting season usually commences in June and ends in December.

The leading varieties grown are Badila, Malabar and Pompey. Badila is the best all round variety, and in 1917 it constituted 97 per cent. of the crop at Lautoka, 97 per cent. at Labasa, 88 per cent. at Rarawai and 32 per cent. at Nausori. At the latter mill Malabar is the leading variety, as it is believed to be the most suitable for the poorly drained flats surrounding that mill. Pompey is now being extensively grown on the second-class lands at Rarawai, and on such soils it seems to give a better financial return than Badila.

The general rotation is a 25 per cent. one, which means that 25 per cent. of the land is under plant cane, 25 per cent. under first ratoons, 25 per cent. under green fallow and 25 per cent. under preparation for replanting. Mauritius bean (*Stizolobium aterrimum*) is the green fallow crop usually ploughed in, although cowpea is also used to a certain extent.

### **The Cane Beetle Borer** (*Rhabdocnemis obscura*, **Boisd.**) (fig. 1).

The beetle borer has long been known as the most destructive pest of sugar-cane in Fiji, where it now constitutes a very serious entomological problem. The available evidence indicates that its original habitat is New Guinea, whence it has spread to North Queensland, Fiji, Samoa, Tahiti, Hawaii and other islands of the Pacific. It is believed that the pest reached Fiji in a consignment of seed cane imported from Hawaii.

The borer shows a marked preference for soft rank cane, and as this occurs most commonly in the heavy crops on rich alluvial flats, it follows that this pest is more destructive on such soils than elsewhere. The amount of damage does not depend solely on the type of soil on which the cane is grown, for it has been found that the susceptibility of the different varieties varies greatly. Badila is a soft sweet cane liable to fall and rot, while Malabar is a hard cane with a low sugar content and with a less marked tendency to fall to the ground when heavy tonnages

are grown, and as the borer prefers soft sweet stalks of cane to tunnel in, it almost invariably happens that on similar types of soil Badila suffers much more severely than Malabar.

The white elongate oval egg of this pest is about one-sixteenth of an inch in length, and is laid in the rind of the stalk behind a half-loosened leaf-sheath, and a week after oviposition the grub hatches out and bores into the cane, becoming full-grown in eight to eleven weeks. In boring the cane the grub destroys a very large amount of tissue, partly by eating and swallowing it, and partly by chewing it to extract the sap. The tunnels made are not infrequently two feet long, but generally they do not extend to more than six inches; in tunnelling the cane the grub frequently eats too close to the rind, and in doing so it makes small rupture holes about the size of a pin's head. The borer grubs can be readily located by the presence of these holes, which stand out somewhat conspicuously as a result of the rind in their immediate vicinity being of a rather lighter shade than elsewhere. The full-grown grub measures somewhat more than half an inch in length, and is legless, wrinkled and yellowish grey in body colour, the head being light reddish brown. The fifth and sixth abdominal segments are greatly swollen ventrally.



Fig. 1. *Rhabdoenemis obscura*, Boisd.,  $\times 3$ .

The full-grown grub prepares for pupation by eating a hole in the rind of the cane somewhat less than a quarter of an inch in length, and at a short distance above this hole it pupates in a cocoon of fibres separated from the tissue in which it has been tunnelling. The cocoon is extremely strong, and as it is very difficult for anything to penetrate it, the pupa is generally immune from the attacks of the small brown ant (*Pheidole megacephala*, F.); were the cocoon less strongly made a large proportion of the pupae would undoubtedly perish, for this ant is extremely voracious and a very formidable predator.

The newly formed pupa is cream-coloured, but as the pupal stage advances the darker markings of the future beetle appear and eventually show up distinctly. The pupa is half an inch in length and the pupal stage lasts for about two weeks. The newly formed beetle rests in the cocoon for a considerable number of days before venturing forth to feed and mate, and when it does so, it leaves the cane by the hole made by the grub prior to pupation. The period that elapses between the laying of the egg and the emergence of the fully hardened beetle is between three and four months. The beetle is half an inch in length and is a typical Curculionid ; the colour is dark brown, broken by several black patches on the thorax and elytra. The sexes can be distinguished by the fact that in the male the rostrum is shorter, straighter, thicker and also rougher on the under surface than in the female (fig. 1).

The damage caused by this pest is often very severe, for it is no uncommon occurrence to harvest fields in which it is difficult to find a single stalk unattacked by it. The percentage of stalks damaged by borers at the Fiji Mills during the 1917 crushing season was 14, a figure that is sufficiently high to cause considerable anxiety. The activities of this pest lead to a very considerable reduction in the crop, for the sugar yield is affected in several ways. In the first place, there is the loss of sugar in the cane tissue swallowed or chewed by the borer grubs, and in badly attacked fields this is very considerable, because many of the stalks are so extensively tunnelled that they contain little or no sound cane. The loss of sugar is not confined to the tissue actually eaten, for it has been shown that the boring of the grubs materially reduces the sugar content of the untunnelled portions of infested stalks. Another source of loss in attacked fields is the increased liability of bored stalks of cane to break and fall to the ground, where they become still further infested and rot rapidly. The general effect of the attacks of this pest is to depreciate the value of a large proportion of the crop on the richer lands, and to render much of it absolutely valueless for milling purposes.

The following control measures have been found to be of great assistance in Fiji :—

(1) Seed cane for replanting fallow fields should be cut in areas known to be free from borer ; where this is not possible the seed used should be carefully inspected, and all infested stalks should be rejected and destroyed.

(2) The trash on badly infested fields should be burned as soon as possible after cutting, as by so doing numbers of beetles underneath the trash and most of the eggs, grubs, pupae and beetles in the discarded cane will be destroyed. Cane stalks that are badly diseased or badly attacked by the borer are generally left on the field, and unless the trash is burned off it finds an excellent breeding ground in such discarded cane. Trash should not be burned on poor land, because on such soils it is necessary to preserve all humus-forming material ; fortunately, however, cane on poor land is seldom badly infested by the weevil, and so there is rarely any necessity for burning trash on such soils.

(3) Fields to be replanted should be ploughed out as soon as possible after harvesting, thus depriving the pest of such an excellent breeding ground as neglected volunteer ratoons.

(4) The beetles should be collected by means of traps of split canes laid in suitable fields. These traps attract large numbers of weevils which can be collected and destroyed.



A prolonged effort was made to increase the efficiency of the control of this pest by the introduction of a Tachinid fly parasite, *Ceromasia sphenophori*, Vill., which was introduced by Mr. F. Muir from New Guinea to Hawaii, where it soon brought about a reduction in the losses on the plantations. As the conditions in Fiji appeared to be favourable to the introduction of the parasite, it was thought possible to repeat the success, and accordingly Dr. J. F. Illingworth, of the College of Hawaii, was commissioned by the Colonial Sugar Refining Company to introduce the parasite to this country. He arrived on 30th May 1913, and succeeded in rearing the parasite in breeding cages, from which he liberated large colonies, all of which failed to become established. He then returned to Hawaii after spending two or three months in Fiji, and from the date of his departure until the end of 1914 the work was carried on by Mr. D. S. North (Mycologist to the Company); from January 1915 to March 1917 the work was superintended by the writer. Mr. North was successful in establishing the parasite in several fields on Natova plantation, and it looked as if success was in sight, but unfortunately this field colony died out shortly after the breeding cage on the plantation was closed. The writer's experience while in charge of the work was similar; so long as the breeding cages were maintained, it was possible to find considerable numbers of parasitised borers in the fields adjoining the cages, but when these cages were closed down the field colonies dwindled and eventually died out; it is thus evident that these field colonies depended for their continued existence on a steady stream of new parasites from the breeding cages; when that steady stream ceased the rate of multiplication in the field seemed unable to counterbalance the very heavy mortality rate, and so the colonies gradually died out. The effort to establish the parasite lasted almost four years, and ended in failure in spite of the fact that very large colonies were liberated, and that at one time breeding work was being carried on at five different centres in order to give the fly a trial under all the different conditions prevailing in the sugar districts. This failure illustrates the uncertainty of all parasite work; for the success in Hawaii seemed to assure an equally favourable result in Fiji. Climatic conditions cannot be held responsible for the failure, for the parasite was bred in very large numbers in captivity, clearly showing that the climate was favourable. The writer is of opinion that the large jumping spiders and the small brown ants, combined with peculiarities in agricultural methods and in the growth habits of the leading variety of cane, have been responsible for this disappointing and unexpected result.

The ease with which this parasite establishes itself when conditions are favourable is shown by the fact that it became established in North Queensland from a few flies that escaped from an intermediate breeding cage used by Muir and Kershaw when they were transporting the parasite from New Guinea to Hawaii.

#### **The Small Cane Beetle Borer (*Trochorrhopalus strangulatus*, Gyl.) (fig 2).**

This weevil is frequently found in cane. It is much smaller than the more destructive species, from which it can be easily separated in the larval, pupal and adult stages. The larva of the larger species has the 5th and 6th abdominal segments distinctly swollen ventrally, a feature which is absent in this insect; and in the pupal stage the two can be readily separated by the fact that the smaller species does not make a cocoon. The adults can be distinguished by their colour, the smaller species being unicolourous, while the larger one has its brown colouring broken by black



marks on the elytra, the thorax and elsewhere. Other less easily observed differences exist, but the above are quite sufficient to separate the various stages.

So far the writer has never observed this species attacking perfectly sound cane, and his experience is that it generally breeds in rotten fallen cane, and less frequently in sickly standing stalks. Were it to turn its attention to sound cane it would undoubtedly become a serious pest, as its rate of multiplication is very great; but at



Fig. 2. *Trochorrhopalus strangulatus*, Gyl., + 5.

present its importance is very slight. The control measures recommended for the larger cane beetle would also be effective with this species.

### The White Grub of Sandy Soils (*Rhopaea vestita*, Arrow) (fig. 4).

White grubs frequently occur in large numbers in certain types of soil, and are often the cause of very severe damage, so serious in fact that several tracts of coastal land have been thrown out of cultivation because of bad infestation. Two species have been found attacking cane on an extensive scale, and being new to science, they have been described by Mr. Gilbert J. Arrow (Ann. Mag. Nat. Hist. (8) xvi, p. 319) under the names of *Rhopaea vestita* and *Rhopaea subnitida*; both species are natives of Fiji.

The local distribution of these grubs is very interesting, for on no occasion has the writer found the two species together in the same type of soil. *R. vestita* has always been found in sandy fields situated close to the coast, while *R. subnitida* occurs in rich alluvial lands and in red hill soils, but not in sandy lands. Although the latter species is found in alluvial soils, it is never present in large numbers and has never been observed doing appreciable damage; for although it undoubtedly attacks the cane, its numbers in such soils are so small that it has no apparent effect on the crop. On several occasions, however, this same species has caused considerable damage on red hill soils. *R. vestita* is responsible for extensive injury year after year on sandy soils, and is by far the more destructive of the two species.

The life-history of *R. vestita* has been more extensively studied than that of *R. subnitida*, and the main features of it are outlined in the following paragraphs.

The finely reticulated, elongate oval eggs are on an average about 2.5 mm. in length and 1.25 mm. in breadth when newly laid, but the egg increases in size as the incubation period advances, and just before hatching it is spherical rather than elongate oval, the diameter being approximately 3.5 mm. The eggs are laid singly at a depth of 15 to 20 inches, having an average incubation period of 31 days, the maximum and minimum being 34 and 28 days respectively. Dissection shows that each of the paired ovaries consists of six tubes each producing three eggs, the maximum number a female lays being 36, although in captivity it is usually considerably less. The eggs are laid from May to September inclusive, the chief egg-laying months being June and July.

The grubs feed on both living and decaying vegetable matter in the soil, very large quantities of soil being swallowed in order to extract this; but living vegetable matter, such as cane roots, is also attacked, and in this respect the damage is particularly severe in January, February and March, i.e., when the grubs are well grown. When full-grown the white grub averages 27 mm. in length and 6 mm. in breadth; the body colour is creamy white, with the exception of the last abdominal segment, which appears greyish black as a result of the contents of the alimentary tract showing through the skin. The great majority of the grubs are found within six or seven inches of the surface of the soil all the year round, and so they are always within reach of the plough.

In April, or even earlier in some cases, the grubs enter the pre-pupal stage which lasts for a couple of weeks, at the end of which time the pupa is formed in an earthen cell at a depth of 6 to 18 inches below the surface. The pupa averages 19 mm. in length and 8 mm. in breadth; the pupal period lasts for 31 days. Pupae are found from April to September, but are most plentiful in April and May.

The beetles do not leave the soil immediately after the transformation from pupa to beetles, but lie resting in their earthen cells for two or three weeks before emerging to feed and mate. Beetles have been found in the soil on 7th February, but this is unusually early, for they do not reach their maximum abundance until June. During the swarming season they are found in thousands on their food-plants, the chief of which are acacias, guavas, coconuts and cane, but for the purpose of mating they will also swarm in large numbers on any prominent object such as windmills, telephone poles or large trees. In the swarming season the beetles emerge about twenty minutes after sunset, and mating proceeds for two hours, after which they settle down on their food-plants, where some of them feed, while others remain quite inactive; shortly before sunrise they return to the soil or to their hiding places under cane trash and fallen leaves. The most prominent feature of this return to the soil is the rapidity with which it is accomplished, as not a single beetle is to be seen a couple of minutes after the first one has taken flight.

The beetle is reddish brown in colour, and is clothed with very small yellowish setae, except on the breast, which is covered with long yellow hairs. The average length is 17 mm. and the average maximum breadth 9 mm.

The life-history may be summarised as follows:—The female lays twenty to thirty eggs singly in sandy soil in June and July at a depth of 15 to 20 inches, and after an incubation period of 28 to 34 days the grubs emerge and feed on humus and

living vegetable matter, being most destructive in January, February and March of the next year, by which time they are nearly full-grown. They pupate in April and May in earthen cells at a depth of 6 to 18 inches, and after 31 days or so in the pupal stage the beetles appear. The adults do not leave the soil immediately after their transformation, but rest in the earthen cells for a week or two, and then emerge to feed and mate and repeat the life-cycle. There is only one generation in a year.

This pest is very destructive on sandy soils, in which it attacks cane of all ages. Fields replanted in January, February and March almost invariably suffer severely, as the grubs at that time are well grown and immediately attack the young plants, destroying the roots, or eating the young shoots at the base and thus severing them from the set and the root system. Many of the attacked plants die, but others survive, although more or less crippled, the older cane being better able to withstand the attacks, as its recuperative powers are greater, but even such crops are frequently severely checked.

The following natural enemies take a heavy toll of the white grubs of this species. The wireworms of *Monocrepidius pallipes*, Esch., attack and destroy the grubs in large numbers, and the Scoliid wasp, *Discolia ovalanensis*, Sauss., parasitises very many of them. An unidentified species of mite attacks the grubs in considerable numbers when kept in captivity, and the attacked individuals generally die. In the field conditions do not seem to be so favourable to the mite, and it is only rarely that one there finds grubs as badly infested as in the laboratory. Minah birds destroy large numbers of grubs during cultivation operations, and are undoubtedly of great assistance in minimising the losses from this pest.

Fields known to be badly infested by white grubs should not be planted until April, as by that time most of the grubs will be in the pupal or prepupal stage, and so the crop will be free from serious attack until December or January, when the cane will be well established and so better able to resist the grub attacks. The collection and destruction of beetles and grubs is also of assistance in controlling this pest, while the frequent ploughing of infested fields will expose many grubs to destruction by minahs.

### **The White Grub of Alluvial and Red Hill Soils (*Rhopaea subnitida*, Arrow) (fig. 3).**

The cane grub of sandy soils has been dealt with in considerable detail in the preceding paragraphs, but a much briefer reference will suffice for the less destructive species, *R. subnitida*, partly because it is of less importance, partly because less detail is required owing to the similarity between the life-histories of the two species, and partly because it has been less closely studied than *R. vestita*.

The seasonal occurrence of the two species is practically the same, and so far the writer has not observed any difference in feeding habits. The beetles eat acacia, coconut, cane and guava leaves, but the amount of food consumed is small.

The beetle, pupa, grub and egg of *R. subnitida* are each larger than the corresponding stages of *R. vestita*. The beetle of the latter species can always be readily identified by the presence of a smooth median area on the pygidium, which in the former is setose all over. The writer cannot distinguish between the pupae and

eggs of the two species, but the well grown grubs are not difficult to separate, as that of *R. subnitida* is more hairy and has longer legs than the grub of *R. vestita*.

The egg-laying records of females kept in captivity and the dissection of ovaries show that in reproductive powers the species are similar. It is therefore difficult to explain why this grub should be so much less numerous than the other. The beetles are just as hardy, and in the laboratory the grubs are not nearly so easily injured as those of the sandy soil species. The explanation of the relative scarcity of this grub will probably be found in the presence of some enemy which attacks *R. subnitida* only and has so far escaped observation, or in the existence of some other adverse factor in the soil types frequented by this grub. This is a point worthy of further investigation.

The control measures recommended for *R. vestita* will also be of assistance in checking the destructive activities of this species.



Fig. 3. *Rhopaea subnitida*, Arrow,  $\times 4$ ;  
a, portion of elytra highly magnified  
to show the scaling.

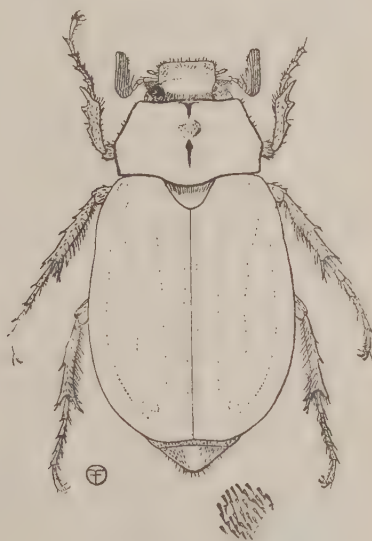


Fig 4. *Rhopaea vestita*, Arrow,  $\times 4$ ;  
a, portion of elytra highly magnified  
to show the scaling.

### The Rose Beetle (*Adoretus versutus*, Har.) (fig. 5).

The rose beetle is not generally regarded as a pest of cane, but on a recent plantation inspection the writer observed the grubs of this species attacking the germinating eyes of cane sets planted some two or three weeks previously.

The grubs of this Rutelid beetle have been found in all types of soil, and almost invariably occur within six inches of the surface. The beetles are found all the year round and are a great nuisance to all rose growers, as they attack and destroy the



leaves of the rose bushes, and in many districts it is impossible to grow roses successfully unless they are screened every evening before sundown.



Fig. 5. *Adoretus versutus*,  
Har.,  $\times 4$ .

The beetle feeds on the leaves of sugar-cane, guava, acacias, cacao and rose bushes. This species is fortunately of slight importance in the cane-fields, and no control measures are required.

#### **The Introduced Parasite of White Grubs (*Scolia manilae*, Ashm.).**

While on a recent visit to Hawaii the writer was much impressed by the degree of success obtained in the introduction of *Scolia manilae*, Ashm., to control the white grubs of *Anomala orientalis*, Waterhouse. This pest was accidentally imported from Japan in quite recent years and is now firmly established on two plantations on the island of Oahu, where it is seriously reducing the cane crops. A considerable number of parasites were introduced to control it, and of these the *Scolia* shows most promise; at the end of 1917 it had become extremely numerous, and showed such splendid prospects of success that the writer determined to take a colony back to Fiji, in the hope that they might attack the Fijian cane grubs and rose-beetle grubs.

The officers of the Hawaiian Sugar Planters Association gave all possible assistance, and supplied laboratory accommodation while the writer was breeding the colony, and also much helpful advice based on their own experience in handling this parasite. The colony was successfully transported to Fiji, and six hundred fertilised females and over two hundred males were liberated in an area that is always badly infested with grubs. It is still too early to say whether or not success has been attained, but the laboratory trials showed promising results, for the parasite attacked the grubs of *R. vestita* and *A. versutus* and laid eggs on them; adult parasites were subsequently reared from some of these eggs. A distinctly unfavourable factor was introduced a few weeks after the parasites were liberated, for a heavy flood occurred, resulting in a large portion of the grub-infested area being under water for a few hours, and if larvae and pupae of the parasite were present in the soil, it is almost certain that a considerable number of them perished.

**The Sugar-Cane Wireworm** (*Simodactylus cinnamomeus*, Boisd.) (fig. 6).

The following species of wireworms have been found in the soils of the Fijian cane-fields: *Simodactylus cinnamomeus*, Boisd., *Lacon stricticollis*, Fairm., and *Monocrepidius pallipes*, Esch. The first two species, but more particularly *S. cinnamomeus*, are very destructive to young cane plants, while the third is distinctly beneficial, as it is a very formidable enemy of the white grubs of *Rhopaea vestita*.

*S. cinnamomeus* is by far the commonest of the three species, being found in all five types of soil, but reaching its maximum abundance in the rich low-lying flats, where it frequently occurs in enormous numbers.

The full-grown wireworm is sub-cylindrical in shape, and measures 25 mm. in length and 2 mm. in breadth. The dorsum varies in colour from a very light brown to a blackish brown, an intermediate shade being typical; the pleura and venter are pale brown. The newly hatched wireworm measures 2 mm. in length, and for a few days is of a semi-opaque white colour, but rapidly assumes a faint brown tint. It grows very slowly, the available evidence pointing to a larval period of not less than three years. The older wireworms under laboratory conditions moult every ten or twelve weeks.



Fig 6. *Simodactylus cinnamomeus*, Boisd.,  $\times 3$ .

This wireworm pupates in a small earthen cell with smoothly plastered inner walls, and ten or eleven days later assumes the adult form. The beetle does not leave the soil immediately after its transformation, but generally rests in its cell for a fortnight or longer before emerging to feed and mate.

The beetles are inactive during the day, and may be found in large numbers hiding behind the leaf-sheaths of cane, maize and various weeds, and in maize cobs, they also hide under lumps of earth on the surface of the soil. Towards dark they become more active and leave their hiding places.

The females lay their eggs in clusters or strings in small cavities formed in lumps of moist friable soil, the number of eggs per cluster or string varying from five to fifty. The elongate oval eggs are pearly white in colour and when newly laid measure 7 mm. in length and 3 mm. in breadth; in the cool months of June and July the incubation period varies from 16 to 19 days.

The ravages of this pest are particularly severe in newly planted fields of cane. Stools of cane of all ages are attacked, but it is only in the earlier stages that the plant succumbs to the injury, for once it is properly established it is well able to survive the attacks of the wireworms, being then sufficiently vigorous to send out new eyes and roots to replace those destroyed by them. The wireworms in newly planted fields commence the attack by eating the butts or the ends of the sets or cuttings of cane, and then five or six days later they turn their attention to the eyes and roots, which by that time, provided germination conditions have been favourable, have started to swell and come away. The small roots are frequently destroyed, and in a bad attack only 20 or 30 per cent. of the eyes escape injury. The wireworm attacking the eye eats a hole at the base and then devours the whole of the softer inner tissues, thus killing it. Eyes that have germinated and sent up shoots nine or twelve inches long are also attacked and frequently so badly damaged that they die off. The greatest damage to the eyes and young roots occurs in the second and third weeks after planting. In a bad attack as many as 75 per cent. of the sets or cuttings are completely destroyed.

Heavy additional expenditure is incurred when a newly planted field is badly injured, for the numerous misses or failures have to be replaced by new sets or transplants, and this is a costly operation, especially if the latter are used.

Preventive and remedial measures are urgently required for the control of this beetle, but unfortunately it seems to be particularly healthy, being apparently free from parasitic and predaceous enemies and also immune to the most virulent poisons; this latter fact was demonstrated in a poisoning trial in which the wireworms feeding on the poisoned cane seemed if anything even healthier than those feeding on the control sets. The following measures have, however, been found very beneficial in minimising the losses:—(1) In fields known to suffer from wireworm attacks it is well to make provision for failures by the continuous planting of a certain proportion of the rows; usually there is a space of at least fifteen inches between the sets or cuttings in the rows, but in continuous planting no such space exists and hence the number of sets per row is much greater than in the ordinary rows. When required the surplus stools in the rows planted continuously should be dug up to fill the blanks or misses in the ordinary rows. This transplanting should be done only in wet weather. (2) Transplants only should be used to fill the gaps, as new sets are at once attacked by the wireworms and many of them are destroyed; the transplants being older are better able to resist the attack, and if good rains fall shortly after transplanting, very few of them fail, and so a full stand of cane is obtained. (3) The cane on alluvial flats should be second ratooned, as by so doing the annual planting area is reduced, and thus the annual loss from wireworms is minimised. (4) Drainage should be improved wherever possible, and the importance of clean cultivation cannot be over-estimated.

### **The Yellow Wireworm** (*Laeon stricticollis*, Fairm.) (fig. 7).

This species is not nearly so destructive as *S. cinnamomeus*, being much less numerous and not nearly so voracious; it is occasionally met with in numbers in alluvial soils and it also occurs in red hill and sandy soils, but is never so abundant as the common species.

The pearly white egg is more nearly spherical than that of *S. cinnamomeus*, and measures .6 mm. in length and .4 mm. in breadth; the incubation period is 12 or 13 days. The larva or wireworm is pale clay-yellow, except for the head, the first thoracic segment and the last abdominal segment, which are brown; the full-grown wireworm measures 18 mm. in length and 2.5 mm. in breadth, and the duration of the larval stage is probably three years or longer. The pupa is



Fig. 7. *Lacon stricticollis*,  
Fairm.,  $\times 4$ .

typical of the ELATERIDAE, and the blunt posterior angles of the thorax serve to identify the pupal stage of this species, as in the other two the posterior angles are backwardly produced as sharp teeth. The pupal stage lasts for 13 or 14 days. The feeding habits of this species seem to be similar to those of *S. cinnamomeus*, and the control measures recommended for that species would be just as effective for this one.

**The Predaceous Wireworm (*Monocrepidius pallipes*, Esch.) (fig. 8).**

This species has been found only in sandy soils in association with the white grubs of *Rhopaeu vestita*, and has never been observed attacking cane. The larva



Fig. 8. *Monocrepidius pallipes*,  
Esch.,  $\times 4$ .

is very similar in appearance and size to that of *Lacon stricticollis*, from which it can be distinguished by the shape of the caudal notch, which in *Monocrepidius* (C572)



*pallipes* is smaller and carries smaller teeth on the margin. The larval stage probably lasts for three years or longer and the pupal stage for nine or ten days.

The most interesting point in the life-history of this species is the fact that it feeds voraciously on the white grubs of *Rhopaea vestita*, and it is undoubtedly one of the most important factors holding that pest in check. It has been observed eating grubs in the field, and in a prolonged laboratory experiment it was found to consume on an average one grub a week; in the experiment referred to, the wireworms were placed in tins containing rich soil, a white grub and a piece of fresh cane, thus giving them the choice of animal food, living vegetable matter and decaying vegetable tissue or humus. The animal food was almost invariably preferred by this species.

### **The Sugar-Cane Army-Worm (*Cirphis unipuncta*, Haw.).**

The caterpillars of this Noctuid moth frequently appear in considerable numbers, and are responsible for an appreciable amount of damage to the younger crops. The caterpillars can be found all the year round, but generally are most abundant in the cooler months. This pest is a notorious enemy of maize and other cereals in the United States, but fortunately the damage in Fiji has never reached serious dimensions.

The most extensive outbreak of this insect in the writer's experience in Fiji occurred in May and June 1918, in young plant fields six to ten weeks old. The caterpillars were in large numbers on ten plantations in the Lautoka and Rarawai Mill districts; no damage was observed in cane older than nine months, and with one exception the attacks were confined to plant crops.

The army-worms shelter during the day in the folded leaves of the central shoot of the cane plant, and after dusk they move out on to the tips of the leaves, where they feed; when they are present in large numbers they frequently strip the leaves right down to the midrib, thus severely retarding the development of the young plant. The young caterpillars feed on the leaves of tender grasses, until they are able to attack the harder tissue of the cane leaves. There are usually five moults at intervals of three to five days, the caterpillar being full-grown in three weeks. The full-grown caterpillar is 36 to 39 mm. in length, and is greenish brown in colour. When ready to pupate it enters the soil and forms an earthen cell at a depth of two or three inches, and inside this it pupates a few days later. The pupal stage lasts ten or eleven days.

This pest is well held in check by its enemies, and its attacks rapidly die down, for parasites and predators take a heavy toll of it. The minah bird destroys numbers of the caterpillars, and a hornet (*Polistes macaensis*, F.) kills even more; the imago of the latter is very fond of the caterpillars, which also form an important item in the food given to its grubs. The Tachinid fly, *Sturmia bimaculata*, Htg., and a Braconid (*Apanteles* sp.) have been bred from this species of army-worm, and the larvae and adults of various CARABIDAE have been found to feed on the caterpillars. Natural enemies are usually sufficient to hold this species in check, but in the event of a serious outbreak resulting from a combination of circumstances unfavourable to the natural enemies it could be controlled by the use of poisoned sprays.

### A Second Species of Sugar-Cane Army-Worm (*Cirphis loreyi*, Dup.).

The army-worms of this species are occasionally destructive in the cane areas although generally their attacks are confined to a few stools along the edges of fields. During a residence of several years in Fiji the writer has seen only one attack in which the damage was at all serious; this occurred in an eleven-month-old crop of plant cane, and was so severe that many of the leaves were stripped down to the midrib. This species occurs in the old world tropics, and in Africa it is a serious pest of maize.

Minahs, hornets and the Tachinid, *Sturmia bimaculata*, Htg., keep this pest in check, and the use of artificial control measures is unnecessary.

### The Mauritius Bean Army-Worm (*Prodenia litura*, F.).

Mauritius bean is extensively used on all the plantations, it being part of the normal rotation to long-fallow land once every four years with Mauritius bean as a covering crop, which is eventually ploughed in as a green manure. The Mauritius bean army-worm occurs in every fallow field and is responsible for a very appreciable check to the growth of the crop.

The eggs of this moth are laid in clusters or nests, each of which contains from 500 to 700 eggs, the usual spots chosen for egg-laying being the leaves of the food-plant. The caterpillars hatch out after an incubation period of three days, and immediately commence eating small irregular patches on the under-surface of the leaves, but as they grow older they eat through the leaf tissue, destroying epidermis, ground tissue and small veins. The caterpillars also attack cotton, tobacco and cacao, and the writer has recently bred them from the fruits of the "ivi" or Tahitian chestnut. They are full grown in three weeks, and then pupate in earthen cells two or three inches below the ground, the moth emerging after a pupal period of eleven or twelve days.

The enemies of this insect are the minah, the hornet and the small brown ant (*Pheidole megacephala*, F.). The ant destroys large numbers of the eggs. Remedial measures are not at present required for the control of this pest.

### The Moth Borer of Cane (*Trachycentra chlorogramma*, Meyr.).

The larvae of this Tineid moth are occasionally found tunnelling cane, and causing a slight amount of damage. Their work has usually been most conspicuous in low-lying reclaimed tiri fields, which frequently contain a considerable proportion of sickly canes. Some of these moth borers have been found in half-rotten cane, but others have been found in soft light-coloured Badila stalks which were standing up well and were far from being rotten, although they were of a somewhat sickly appearance. No stools of perfectly healthy cane have been attacked by this insect. The full-grown larva is about 25 mm. in length, and lives in a case which it drags about from place to place; this case is a spun web to which numerous small particles of cane, earth and vegetable debris are attached. The case affords a considerable amount of protection to the larva, which is able to wriggle into or out of it with astonishing rapidity.

The damage caused by this species bears some resemblance to the work of the beetle borer, but it differs from it in several important respects. The tunnels of the moth are wider, shorter and more irregular than those of the beetle borer and they

contain a much rougher, darker coloured frass. Other points of importance in the mode of attack of this pest are firstly the fact that, unlike the beetle borer, it swallows all the cane it chews, and secondly that it frequently leaves its tunnel and moves up the cane-stalk or even to another stalk, where it commences a new tunnel. Otherwise the larva destroys cane in a manner somewhat similar to the beetle borer by eating tunnels along the stalks, destroying large quantities of tissue and lowering the sugar content of the untunnelled portions of the affected stalks.

The full-grown larva pupates in an extremely tough case made of small pieces of cane fibre overlapping each other like roofing tiles ; it is securely closed at both ends and must afford very good protection to the pupa. The pupa is formed sometimes in the old larval tunnel, and at other times behind the leaf-sheaths or under debris, the pupal period lasting for three weeks.

The burning of the trash after harvesting and the exposure of tunnelled stalks to the heat of the sun will largely check the increase of this insect should it ever show signs of attacking sound cane.

### **The Cane Leaf-Miner (*Cosmopteryx* sp. n.).**

The larva of this very small and beautiful moth mines in the midribs of cane, being particularly abundant in young plant fields, where it does a slight amount of damage by tunnelling along the midrib, interfering with the supply of sap to the leaves and discolouring the tissues surrounding its tunnels. This species is well controlled by parasites.

### **The Hornet (*Polistes macaensis*, F.).**

The common hornet of the cane-fields is far from being a pest, but it is so intimately connected with the sugar plantations that no reference to the insects of the cane-fields would be complete without an outline of its life-history.

This hornet is only a recent introduction, but it has already become one of the commonest insects in the islands, and has probably attracted more general interest than any other species in Fiji. It is widely distributed throughout India and the East, and appears to have reached these islands some fifteen years ago, having in all probability been introduced on a labour ship from India. It showed up first at Suva and has now spread all over Viti Levu ; it has also gained a footing in Vanua Levu, and in a few years time it will doubtless be generally distributed throughout the islands.

The life-history of this species may be summarised as follows :—A fertilised female that has hibernated during August and September commences nest-building at the beginning of October. The cells of the nest are made of the usual fibrous material mixed with cement, and in each the female lays a small greyish white egg from which the young larva hatches in a few days. At first the larva is fed on sugary substances, but after it is a few days old the diet is changed to an insect one. The larva pupates 14 to 18 days after hatching, and the imago emerges after a pupal period of 15 or 16 days; after the emergence of the first new generation progress on the nest is very rapid, and by April it may be as large as 12 inches in diameter. Towards the end of April males and females appear in equal numbers whereas previously the new hornets emerging were nearly all females. This last generation leaves the nest and the hornets hide in sheltered spots, emerging on sunny days in June and July to mate, but by the



end of the latter month mating has ceased and all the males are dead. The females hibernate for seven or eight weeks during August and September, and then they reappear and commence nest-building.

This species is a desirable addition to the Fijian fauna, because it acts as a useful check on many pests. The writer has observed the hornets feeding pieces of caterpillars, flies and grasshoppers to their larvae, while the hornet itself has been seen eating full-grown crickets, young grasshoppers, army-worms, jumping spiders, flies and small beetles.

The sting of this species is very painful, and therefore many people, losing sight of its value as a predator, have passed a verdict of unqualified condemnation on it. While it is true that labourers and others, including the writer, are sometimes badly stung, yet it is fortunate that during the height of the cane-cutting season the hornets are hibernating, and so the labourers can work without fear of being stung. At the beginning of the season a few nests are met with and towards the end of the season the small new nests begin to show up, but even then the danger is not nearly so great as it would be were the cane cut from January to April, when the nests are large and defended by numerous individuals. During the early months of the year there is little occasion for going into big cane at Lautoka, Rarawai and Labasa Mills, and so the labourers do not generally encounter the hornet at its worst; but at Nausori Mill the position is different, for there the usefulness of the hornet is distinctly lessened by the fact that the cane is trashed during the season when the nests are at their maximum size, and considerable expense is incurred in sending special labourers (in canvas suits, gloves and veils) into the cane to destroy the nests before the ordinary labourers can enter the field to trash the cane. The trashing of cane has now been abandoned at the other three mills, being regarded as an unprofitable measure under the climatic conditions of the dry districts.

### **The Leaf-Hopper (*Perkinsiella vitiensis*, Kirk.).**

This pest can be found in any cane field, but fortunately it does little damage, as it is kept in check by numerous natural enemies, the most effective of these being the egg-parasites *Ootetrastichus*, *Paranagrus* and *Anagrus*. The Stylopid parasite, *Elenchus tenuicornis*, Curt., attacks both young and adults, and the numerous spiders in the cane-fields also take a heavy toll of this pest.

The eggs of this leaf-hopper are laid beneath the epidermis of the cane plant, usually along the midribs of the leaves, but also in the internodes of the stalk, or even in the leaf-sheaths; generally three eggs are laid in each cavity, the position of which is indicated at first by the piece of white wax covering the opening of cavity, and later by the reddish discoloration of the tissues surrounding it.

The young leaf-hoppers hatch out and feed on the cane, sucking the sap and excreting honey-dew, on which a black fungus grows. In Fiji the writer has never seen the leaf-hopper present in numbers large enough to stunt the growth of the crop appreciably, and control measures are unnecessary.

### **The Mauritius Bean Bug (*Brachyplatys pacificus*, Dall.).**

This little black Pentatomid bug occurs wherever Mauritius bean is grown, and it can also be found feeding on a number of the leguminous weeds that flourish along the



drains and roads on the plantations. If the upper leaves of any bean plant be pushed aside the bean bug can often be found in such numbers that the stem of the plant is literally black with them.

The bug is 5 mm. in length and belongs to the sub-family SCUTELLERINAE. The eggs have been found on the leaves of Mauritius bean, on the leaves of the commoner weeds of the cane-field, on pieces of timber lying in fields and even on the doors and window-sills of bungalows. The eggs are laid in a double row, the number in each set varying from ten to thirty. Each egg is about one millimetre in length and is an extremely neat white cylinder with a little lid that is opened when the young bug emerges; in most cases the lid falls off when the bug leaves the egg, but sometimes it remains hanging half open as if it were hinged to the cylinder. The eggs are laid end to end in a double row with the lid ends directed outwards. They hatch out after an incubation period of six or seven days.

The newly emerged bugs immediately start sucking the plant sap. They moult frequently, but the exact number of the moults and the intervals between them have not yet been definitely ascertained. The numbers of this pest are often so great that they considerably retard the growth of the green crop, but the damage is not sufficiently serious to warrant the adoption of control measures. The multiplication of the bugs is checked by a Chalcidid egg-parasite described by Mr. J. Waterston as *Ooencyrtus pacificus*, and an important fungous enemy is an unidentified species of *Isaria* which attacks the nymph and imago.

### **The Cane Aleurodid (*Aleurodes comata*, Mask.).**

This Aleurodid is occasionally found in extremely large numbers on the under surface of cane leaves, but as a rule it is not common, and even in its worst attacks it is only a minor pest.

The pale yellow eggs are attached to the leaves and are usually found in clusters containing sometimes as many as 150 eggs. The various stages are all typical of this family.

The damage to the cane is twofold; for in the first place, it is stunted by the loss of sap sucked out of the tissues by the Aleurodid, and in the second place, a sooty fungus grows on the excreted honey-dew and interferes with the process of photosynthesis.

The most effective check to the increase of this pest is the maggot of a Syrphid which feeds on all its stages. The life-history of this predator has been worked out and is briefly as follows. The white cylindrical egg of the Syrphid is firmly cemented to the underside of the cane leaf, and is almost invariably laid alongside an actively ovipositing Aleurodid. The young maggot hatches out in three days, and immediately starts to feed voraciously, attacking all stages of the pest, but seeming to prefer the eggs and the adults to the larvae and pupae. The quantity of food consumed is enormous, as is illustrated by the fact that a single maggot has been observed to destroy as many as one hundred eggs in a day, as well as a considerable number of adults; while another was seen destroying thirty eggs and four adults in twenty minutes. The maggot is typical of the Syrphid family, and is full-grown in seven or eight days; it forms a greenish pear-shaped pupa, from which the adult emerges six days later. This Syrphid is an unidentified species of *Xanthogramma*.

**The Cane Mealy-Bug (*Pseudococcus bromeliae*, Bouché).**

This mealy-bug is often found at the nodes of the cane-stalks behind the leaf-sheaths, where it punctures the rind and sucks the sap, thus lowering the vitality of the plant. It rarely occurs in large numbers and is of only slight economic importance.

The older females are quite inactive, but the young nymphs move about freely until they find a suitable spot at which to pierce the rind of the cane; when once that is found they become very sluggish, and settle down to feed and reproduce.

**Locusts (*Locusta danica*, L., and *Cyrtacanthacris guttulosa*, Walk.).**

These two species sometimes become numerous along the edges of fields, stripping the cane leaves down to the midribs, but the damage is rarely serious. The minah bird is a very efficient check on the locusts, which form its principal food; whenever trash or any rubbish is being burned off in a field the minahs gather in large flocks round the edges and reap a rich harvest from the insects that are driven before the fire and smoke; these consist very largely of grasshoppers.

*Conclusion.*

The three most important pests in the cane fields are undoubtedly the beetle borer, the wireworm and the white grub, each of which constitutes an entomological problem of the greatest importance. Their life-histories have been as fully studied as the time at the writer's disposal permits, but there are still many points of the greatest importance that require investigation in the immediate future. Although much research work remains to be done, a number of satisfactory control measures have been evolved, and their enthusiastic adoption will undoubtedly lead to a great reduction in losses; while there is every reason to believe that with an increasing knowledge of the habits of these pests further and still more effective measures will be devised.

The other pests more briefly referred to in these notes are of minor importance only, and although they have to be recognised as injurious on the plantations, the damage they cause is at present so slight that control measures are unnecessary.

In conclusion, the writer has to acknowledge the courtesy of the Imperial Bureau of Entomology in identifying the species referred to in these notes.

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## A NEW LYGAEID BUG FOUND AMONG STORED RICE IN JAVA.

By W. L. DISTANT.

Dr. Guy A. K. Marshall, Director of the Imperial Bureau of Entomology, has requested me to identify four specimens of a Lygaeid sent to him by Dr. C. J. J. Van Hall from Java, where it was found among stored rice. It is a very distinct species and represents a new genus of which I here give figure and description.

Fam. LYGAEIDAE.

Subfam. APHANINAE.

Div. MYODOCHARIA.

**Ampera**, gen. nov.

Head about as long as anterior lobe of pronotum; first joint of antennae a little shorter than head; pronotum longer than broad, transversely constricted before middle, collar narrow, anterior lobe distinctly globose, posterior lobe strongly centrally longitudinally incised, the basal lateral angles subnodulose prominent; scutellum broadly subangulate; rostrum with the first joint slightly passing base of head—imperfectly seen in carded specimens; anterior femora moderately incrassated; other characters generally as in *Pamera*, from which it principally differs by the structure of the pronotum and scutellum.

**Ampera intrusa**, sp. nov. (fig. 1).

Head, anterior lobe of pronotum and scutellum, black or blackish, posterior frontal lobe more castaneous; corium more or less stramineous, the apical area more or less infuscate; membrane black or piceous, body beneath blackish; legs pale stramineous;



Fig. 1. *Ampera intrusa*,  
Dist., sp.n.

second joint of antennae considerably longer than first; membrane not or very slightly passing abdominal apex; rostrum stramineous, imperfectly seen in carded specimens.

*Var.* Head and pronotum and body beneath, dark ochraceous.

Other structural characters as in generic diagnosis.

Long,  $3\frac{1}{2}$ –4 millim.

JAVA (Dr. Van Hall—from stored rice).





## A USEFUL BREEDING CAGE.\*

By LAURENCE D. CLEARE, JNR., F.E.S.,

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Entomological investigations in the tropics usually entail a certain amount of difficulties not experienced in temperate regions, and it is often necessary to devise various kinds of apparatus to overcome these. The breeding cage described here was devised by myself as the result of a number of difficulties experienced in breeding experiments. Cages of this type have been in constant use in this laboratory for the past four years and have been found to meet almost every requirement. The ease with which they are constructed, together with the possibility of varying their size to suit one's needs, as well as their portability, are all highly commendable features.



Fig. 1. A portable breeding cage

The cages are composed of cylinders of brass mosquito-proof wire netting, 20 meshes to the inch, held together by brass paper-fasteners. To the top and bottom of these cylinders covers are fitted. In this laboratory large glass petri dishes, between 8 and 10 inches diameter, are used for this purpose. Galvanised iron pans may, however, be used instead of these dishes, and if made in nests would be a decided advantage when travelling; the wire being carried in rolls. It will be seen that the diameter of these cages is limited only by the size of the pans, while the height can be

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varied from 3 feet, the width of the netting, down to a few inches. If it is desirable to use cages taller than 3 feet, and this will only be very rarely, the height may be increased by joining on an additional strip of netting by means of paper-fasteners.

Originally, fine muslin, held in place by rubber bands, was used for the tops of these cages; but after some large larvae were attacked by rats the dishes came into use. Obviously muslin can still be used in certain places with advantage, especially when weight has to be considered.

The wire netting is usually fitted inside the dishes both top and bottom, but in cases where earth is necessary for pupation it is advantageous to fit the cylinder outside the bottom; the advantage of this will be found when lifting off the wire to replace the food-plant. Food-plants, of course, have their stems placed in small bottles or other receptacles containing water.

Cages of this type have been used in tick breeding experiments by Mr. G. E. Bodkin, and when thus employed were placed in larger dishes containing water and kerosene oil to prevent the escape of the ticks. This method could also be used to prevent attacks of ants, which, in this Colony at least, have always to be considered in insect breeding.

It may here be mentioned that in this laboratory all tables used for breeding experiments are kept standing in bowls containing water and kerosene oil. Were the bare wooden legs of a table placed in this mixture the oil would penetrate the wood and ruin the legs. Professor Harrison has devised a method to avoid this; small iron rods about 6 inches long and 1 inch in diameter are driven perpendicularly into the legs and it is these that come in contact with the mixture of oil and water.\*

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\*[As an alternative to water and kerosene, dusting the saucers occasionally with pyrethrum powder has been found very effective in keeping off ants; this has the advantage that the legs of the table require no special adaptation.—ED.]

## NEOTOXOPTERA VIOLAE, THEO., AND ITS ALLIES.

By A. C. BAKER, B.S.A., Ph.D., U.S.

*Bureau of Entomology, Washington, D.C.*

(PLATE I.)

In 1915 (Bull. Ent. Res. vi, p. 131) Theobald described an Aphid taken on violets in Africa as *Neotoxoptera violae*. He has also recorded a statement by Davis that it probably is *Rhopalosiphum violae*, Pergande, 1900 (The Entomologist, xlix, p. 149).

A study of Pergande's species as it is to be found in greenhouses in the United States and Canada shows that the form described by Theobald is really an aberration from Pergande's species. This is shown clearly by the figures accompanying this note. Figure 1 is the typical forewing of *violae*, Perg., and from examples of this type aberrations have been found as shown in figures 2 to 6. It will be noticed that there are several cases in which the media is once branched, the condition met with in Theobald's form. Figures 4 and 6 show a much greater departure from the type, and yet these forms as well as all the others figured can be obtained from one colony and in one "family" of the species. The hindwing as figured by Theobald is quite typical for Pergande's species (fig. 7), but here also figures 8 and 9 represent in each case an aberrant form.

The writer is unable to state that similar conditions would be met with also in Africa and that all of these types would occur. From the fact that they occur in America, and bearing in mind that nearly all the allies of this species present similar conditions, one would expect to find them.

In order to understand the proper generic designation for this species it is necessary to review briefly the small group to which it belongs. In the subfamily APHIDINAE there is small group, the PENTALONINA, the members of which are mostly tropical or subtropical. This is based on *Pentalonia nigronervosa*, Coquerel, 1859 (fig. 10), an Aphid with most remarkable venation. This venation, as far as the writer's experience goes, is constant, although no large rearings have been made. To understand this venation it is only necessary to look at *Idiopterus nephrolepidis*, Davis, 1909, and some aberrant forms of this species, which forms, by the way, are not at all rare. Figure 11 shows the typical fore-wing of this insect; here the radial sector is quite distinct. In figure 12 this is seen to be coalesced with the media in such a way as to produce a closed cell comparable to the closed cell in *Pentalonia*. Figure 13 is one of another aberration in which the media does not exhibit its typical forked character.

In 1915 Del Guercio (Redia, vii, p. 463) erected the genus *Fullawayella* for *Macrosiphum kirkaldyi*, Fullaway, 1909. This insect is closely related to *violae*, Perg., but differs in the dilation of the cornicles and other details. In describing the species Fullaway (Ann. Rep. Haw. Agr. Exp. Stn. 1909, p. 22) stated that the venation is normal, that is for *Macrosiphum*, but he figured what evidently is an aberration similar to those found in other and related species (fig. 15). It seems evident that *violae*, Perg., and *kirkaldyi*, Fullaway, belong to the same genus, and it is equally evident that it is not *Rhopalosiphum*, the type of which is *nymphaeae*, Linn. Essig (Pomona College Jl. Ent. iii, p. 541) has stated that he believes *kirkaldyi* and



*nephrolepidis* to be identical and treats the species as a native of the Hawaiian Islands imported into the United States. While this view may be correct, the figures given by Fullaway do not agree, as far as the cornicles are concerned, with any specimens of *nephrolepidis*. They do agree, however, in being swollen somewhat like those of *Micromyzus nigrum*, V. d. Goot, 1916. We have been unable to study the type of the species, and since Essig's view is a surmise, we consider *kirkaldyi* to be distinct from *nephrolepidis* as indicated by Fullaway's figures..

The genus *Micromyzus* was erected by Van der Goot for his new form, *nigrum* (fig. 16) (Cont. à la Fauna des Indes Néerland. i, fasc. 3, p. 52, 1916). *M. nigrum* is undoubtedly closely related to *kirkaldyi*, if Fullaway's figures are correct, and is congeneric with it. *Micromyzus* must therefore fall for *Fullawayella*.

One other genus which evidently belongs to this group has been described (Patch, Ent. News, xx, p. 338, 1909). This is *Microparsus*, with *variabilis* Patch (fig. 14) as type, a form which was first figured and described by Sanborn but not named by him. This species, like the others in the group, shows aberrations.

The different genera and species may be separated as follows:—

- |  |       |                               |
|--|-------|-------------------------------|
| 1—Forewing with a constant closed cell   | .. .. | <i>Pentalonia</i> .           |
| <i>a</i> —Veins heavily bordered   | .. .. | <i>nigronervosa</i> , Cql.    |
| <i>a</i> <sup>1</sup> —Veins not heavily bordered  | .. .. | <i>caladii</i> , V. d. Goot.  |
| 1 <sup>1</sup> —Forewing typically without such cell   | .. .. | 2.                            |
| 2—Hind wing with one vein only   | .. .. | <i>Microparsus</i> .          |
| <i>a</i> —One species only   | .. .. | <i>variabilis</i> , Patch.    |
| 2 <sup>1</sup> —Hind wing typically with more than one vein                                  | .. .. | 3.                            |
| 3—Cornicles cylindrical  | .. .. | <i>Idiopterus</i> .           |
| <i>a</i> —One species only   | .. .. | <i>nephrolepidis</i> , Davis. |
| 3 <sup>1</sup> —Cornicles more or less swollen   | .. .. | <i>Fullawayella</i> .         |
| <i>a</i> —Cornicles broadly swollen  | .. .. | <i>b</i> .                    |
| <i>a</i> <sup>1</sup> —Cornicles slightly swollen  | .. .. | <i>c</i> .                    |
| <i>b</i> —Cornicles very broadly swollen and distinctly reticulate near distal extremity     | .. .. | <i>tulipaella</i> (Theo.)     |
| <i>b</i> <sup>1</sup> —Cornicles moderately swollen and not reticulate near distal extremity | .. .. | <i>violae</i> (Perg.)         |
| <i>c</i> —Segment iv of antenna without sensoria   | .. .. | <i>kirkaldyi</i> (Fullaway).  |
| <i>c</i> <sup>1</sup> —Segment iv of antenna with 3–5 sensoria                               | .. .. | <i>nigrum</i> (V. d. Goot).   |

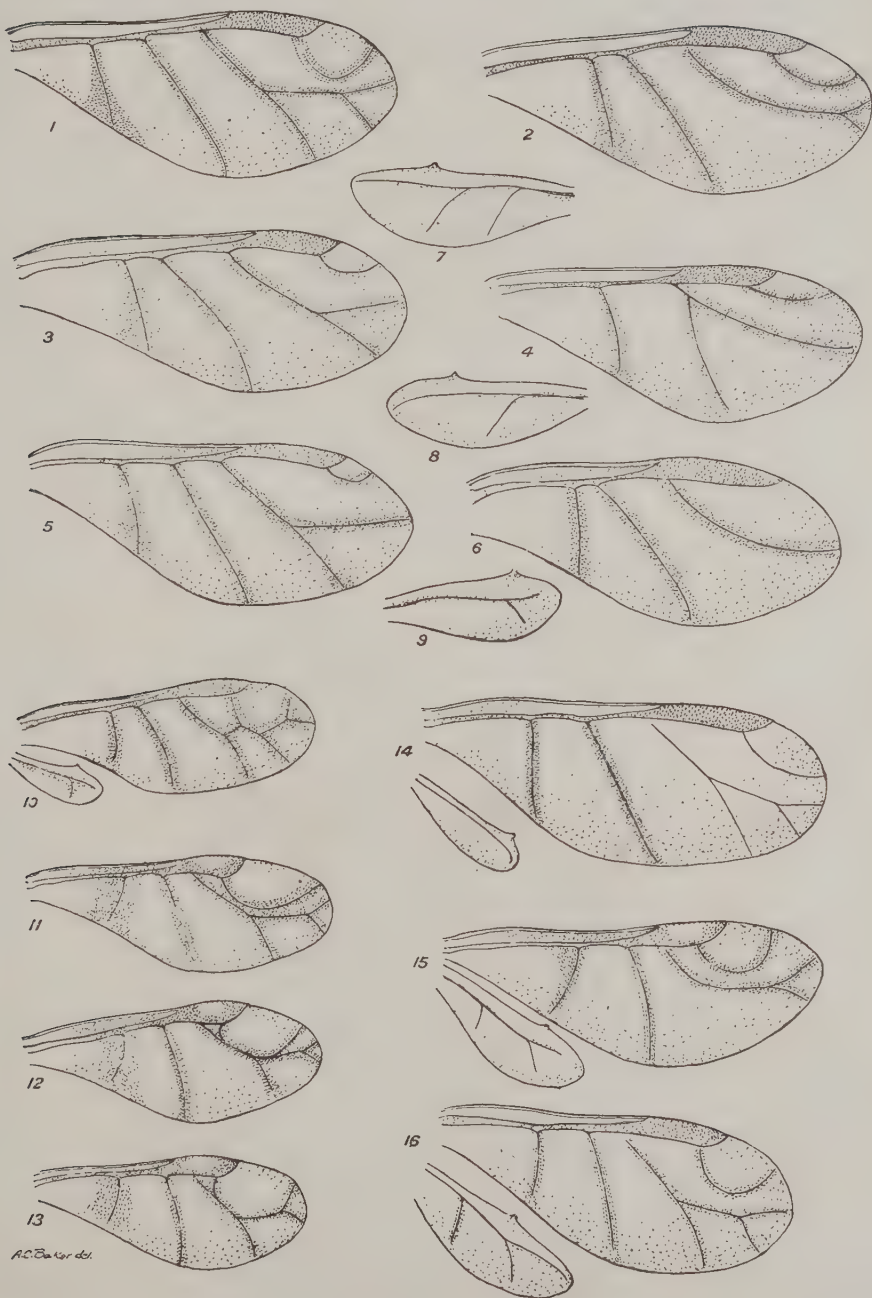
Of the species in the key only two, *violae*, Perg., and *nephrolepidis*, Davis, have been studied with a view toward determining the commonly present aberrations. If the opportunity to study other species in this way should arise, it is not improbable that other names would sink in synonymy. This brings up again the question of the advisability of retaining a name, in a lower category than a species, for an aberration or of giving names to such forms if undescribed. In some groups of the APHRIDIDAE these forms are remarkably abundant and their naming would place in the literature an almost endless series of designations. If, however, certain of these forms were found constantly in certain regions (as for example if the *violae* of Theobald, as he believes, is a somewhat fixed African form) it would seem advisable for the sake of convenience to use some designation for them.



## EXPLANATION OF PLATE I.

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- Fig. 1. *Fullawayella violae*, Perg., forewing, typical.  
2-6. „ „ „ aberrations.  
7 „ „ hindwing, typical.  
8-9. „ „ „ aberrations.  
10. *Pentalonia nigronervosa*, Coq., wings.  
11. *Idiopterus nephrolepidis*, Davis, forewing, typical.  
12-13 „ „ „ „ aberrations.  
14. *Microparsus variabilis*, Patch, wings.  
15. *Fullawayella kirkaldyi*, Full., wings.  
16. „ *nigra*, v.d. Goot, wings.
-



A.C. Benoit del.

*Neotoxoptera violæ*, Theo., and its allies.





## THE DOMESTIC BREEDING MOSQUITOS OF THE NORTHERN TERRITORIES OF THE GOLD COAST.

By A. INGRAM, M.D., C.M.,  
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The work of Dr. J. J. Simpson (Bull. Ent. Res. v, pp. 1-36 and Bull. Ent. Res. viii, pp. 193-214) has added largely to the knowledge of the bionomics of the larger blood-sucking insects of the Gold Coast, especially of the Northern Territories of the Colony, yet up to the present time, with the exception of the records obtained from one or two stations, singularly little is known with regard to the distribution in the Northern Territories of the smaller blood-sucking insects such as mosquitos and "sandflies."

It was therefore determined, when instructions were received from the Hon. Principal Medical Officer to accompany him on a tour round the Northern Territories with a view to determining the prevalence of *S. fasciata*, F., to take the opportunity of recording the distribution of as many other species of mosquitos and "sandflies" as possible.

The tour occupied about three months, the Northern Territories being entered on the 3rd May and left on the 2nd August 1918. It must be confessed that the results obtained were disappointing; this is to be attributed (a) to the exceptional dryness of the season, (b) to the short halts—less than 24 hours—made at the majority of places, and (c) to the difficulty of hatching adult mosquitos from larvae and pupae "en route," few larvae and fewer pupae surviving the continous jolting to which the water in the breeding jars was submitted when borne on the head of a carrier. So far as the commoner mosquitos were concerned the death in the pots of their larvae or pupae was unimportant, as identities could generally be established from an examination of the dead larvae or pupae; but unfortunately on one or two occasions larvae or pupae which were not known were collected and as these succumbed without hatching the identity of their imagines is yet to seek.

A routine plan of working was adopted and adhered to as closely as possible throughout the tour. A visit was made to the native compounds each evening between 5 and 6 o'clock to search for collections of water containing larvae or pupae of mosquitos; when these were found, samples of the contents were transferred to glass jars and the top of the jars covered with fine-meshed gauze. These jars were carried along from day to day till adult mosquitos had hatched or the larvae and pupae had died. In the case of small villages every compound was visited, but in the case of the larger villages or where the individual compounds were several hundred yards apart, as in the Frafra, Grunshi and Lobi countries, only half a dozen of the compounds nearest to the Rest House were examined.

Trees growing in close proximity to the Rest Houses were scrutinised carefully for "rot" holes, which are known to form a favourite habitat of larvae and pupae of certain mosquitos, e.g., *Stegomyia*. The walls of the Rest Houses were examined each day for *Phlebotomus* and every evening when sitting out in the open air a look out was kept for *Culicoides*.

The accompanying map shows the places where *S. fasciata*, F., was found, and it will be seen that its distribution is practically universal throughout the districts traversed. In the diary attached its presence is not recorded at several of the halting places, but probably this is due to insufficient observation; with the exception of Yeji it is recorded from all the principal stations. The returns from the



○ Indicates places where *Stegomyia fasciata* has been found.

□ Indicates present or former European stations where *S. fasciata* has been found.

majority of places stopped at merely show the presence of such mosquitos as breed in the collections of water in the immediate neighbourhood of human dwellings and, as has been pointed out elsewhere (Bull. Ent. Res. vii, pp. 171-172), returns of mosquitos bred from domestic utensils convey a false impression as to the actual

indigenous "domestic" mosquitos of any place. Where a halt of three or four days was made and it was possible to go further afield in search of larvae, Anophelines were invariably found.

Larvae of six species of mosquitos were commonly found in the various collections of water encountered in the native compounds and houses, namely:—*S. fasciata*, F., *S. vittata*, Big. (*sugens*, Theo.), *Culicomyia nebulosa*, Theo., *Culex duttoni*, Theo., *C. decens*, Theo., and *C. tigripes* var. *fuscus*, Theo. Larvae of *A. costalis*, Loew, and *Culex invidiosus*, Theo., were also taken in domestic utensils, but they were far from common.

As regards the habits of these mosquitos, it was noticed that larvae of *C. duttoni* were usually found in water in pots that had been used for the brewing of "peto" (native beer) or had contained that liquid. "Peto" has a characteristic sour odour which is very persistent and clings for long to any vessel that has contained it. Larvae of *C. duttoni* were never found at any distance from human habitations, except at Tumu, where they were discovered in a small pool near the swamp at a distance of about 500 yards from the nearest hut; this particular pool it was afterwards ascertained was made use of by the natives for the purpose of cleansing their "peto" pots. Larvae of *C. decens* and of *Culicomyia nebulosa* were generally discovered in utensils holding foul water, often associated with larvae of *C. duttoni* and larvae of *C. tigripes* and occasionally with larvae of *S. fasciata*. "Peto" pots apparently offered no attraction to the adult females of these two species. Larvae of *C. tigripes* were found indifferently in vessels containing fresh or foul water; possibly the adult female lays her eggs only in water which she knows instinctively to contain eggs or larvae of other species of mosquitos.

Larvae of *S. fasciata* and *S. vittata* were frequently found associated, usually in clean water. The commonest receptacles containing these larvae were small earthenware pots or portions of calabashes used for holding the drinking water for the fowls belonging to the compound. It is to be noted that *S. vittata* is not solely a "domestic" breeder; larvae of this species may be found in enormous numbers in shallow pools formed by the weathering of outcrops of gneiss (?) and laterite far from any human habitation. Apparently, as has been recorded by Bacot, this species passes through its cycle of development at a very rapid rate, and perhaps it has been compelled to do so by the rapid evaporation of the water from these pools under the influence of the tropical sun. Larvae of *Culicomyia nebulosa* were also occasionally found in pools in the "bush" at great distances from the villages.

Larvae of *C. invidiosus* were quite common in swampy pools in the "bush," while they were only rarely found in collections of water in the native compounds. On the other hand, larvae and pupae of *C. decens*, which so closely resemble those of *C. invidiosus*, were not met with in swamp pools, but abounded in domestic utensils.

Larvae of *C. ager* var. *ethiopicus*, Edw., were taken only in swamp pools in which filmy algae (*Spirogyra*?) were growing; the tint of these larvae is almost the same as that of the algae and is doubtless an instance of protective colouring (cf. larvae of *Culex annulioris*, Theo., and *C. consimilis*, Newst.). Larvae of *Anopheles pretoriensis*, Theo., were found at Winduri in rock pools in association with larvae of *Stegomyia vittata*.



In many of the trees in the neighbourhood of European quarters and Rest Houses "rot" holes were found; with the exception of three, which contained water and mosquito larvae, these holes were either absolutely dry or showed very slight moisture, but as many of them proved capable of holding water, this dryness was probably due to the dearth of rain. The debris collected in 25 of these holes was scraped out and, after thorough drying in the shade where there was any indication of moisture, was preserved with a view to testing it for the presence of "resistant" eggs. Twelve of these samples were experimented with whilst the tour was in progress, but in no instance did any mosquito larvae hatch. As it was thought that the conditions obtaining "en route" were not ideal for the hatching of larvae, the remaining samples were brought back to Accra, where after being immersed in water they were kept under observation for a period of one month without appearance of larvae. It seems open to doubt whether *Stegomyia fasciata* and other species of this genus tide over the dry season in the Northern Territories by means of "resistant" eggs stranded in "rot" holes of trees.

Portions of the leaves and twigs of those trees near the dwellings which seemed to show "rot" holes most commonly were collected for identification purposes and were forwarded to the Director of Agriculture at Aburi. *Poinciana regia*, the flamboyant (often planted for ornament near European houses), wild fig trees, mangoes, silk-cotton trees, "dawa-dawa" trees (*Parkia biglobosa*) and tamarinds were frequent offenders in this respect.

With regard to the above-mentioned specimens of trees the Senior Curator of the garden at Tamale, to whom they were submitted for identification by the Director of Agriculture, writes under date 23.xii.1918 as follows:—"Specimens received; I will do all I can to obtain full botanic names, but it will take some time. Most of the trees grow in districts remote from Tamale. . . . As regards the point raised by Dr. Ingram about these trees developing "rot" holes, (this) might be applied to any tree growing in the Northern Territories large enough to afford firewood. Live branches are hacked off to be dried for firewood, causing jagged wounds which soon develop into "rot" holes; rather the treatment than the tree." The trees, however, from which the specimens in question were obtained were those growing close to the quarters of the European officials in the stations or those in the compounds of the European Rest Houses; such trees are not usually made use of for firewood by the natives, but are carefully preserved for shade or for ornamental purposes.

The compounds of 44 villages and towns in the Northern Territories were visited and samples of mosquito larvae were obtained from 42. In 34 of the villages and towns larvae of *S. fasciata* were found (77 per cent.), in 35 larvae of *Culex duttoni* (79 per cent.), in 23 larvae of *C. decens* (52 per cent.), in 21 larvae of *C. tigripes* (47 per cent.), in 21 larvae of *Culicomyia nebulosa* (47 per cent.), in 20 larvae of *S. vittata* (45 per cent.), in 4 larvae of *Anopheles costalis* (9 per cent.) and in 3 larvae of *C. invidiosus* (6·8 per cent.). It may be of interest to compare these figures with the records of domestic breeding larvae obtained at Accra during the past two years. Of 1,121 samples of larvae collected by the sanitary inspectors and forwarded to the Laboratory for examination, *S. fasciata* occurred in 876 (78 per cent.), *Culex fatigans* in 221 (19·7 per cent.), *A. costalis* in 43 (3 per cent.), *C. decens* in 20 (1·7

per cent.), *C. invidiosus* in 18 (1·6 per cent.), *C. duttoni* in 5 (0·4 per cent.), *C. tigripes* var. *fuscus* in 3 (0·2 per cent.) and *Culicomyia nebulosa* in 1 (0·08 per cent.). It will be noticed that with the exception of two, namely *C. fatigans* and *S. vittata*, the species found in Accra and in the towns and villages of the Northern Territories are identical. *C. fatigans* has yet to be recorded from the Northern Territories and *S. vittata* from Accra. An erroneous impression is apt to be given by the above figures, as although *S. fasciata* was found in 77 per cent. of the villages and towns visited, it is to be remembered that it was specially looked for and in many instances was not found without prolonged and careful search. It is a much rarer mosquito in point of numbers in the Northern Territories than in Accra and in the coast towns generally. The possible effect upon disease and its transference of the higher proportional representation of the other domestic Culicines in the Northern Territories, as compared with Accra, is an interesting subject for speculation.

Filariasis and diseases usually associated with *Filaria bancrofti* are stated by Medical Officers who have been stationed on the northern boundary of the Northern Territories to be common; if this be the case the rôle played by *Culex fatigans* must be taken by some other species. *A. costalis*, *Mansonioides uniformis* and *S. fasciata* are recognised potential carriers, and *Culex duttoni* "was found to be one of the hosts of *Filaria nocturna* by Dr. Dutton" (Theobald, Appendix to Report of the Malaria Expedition to the Gambia 1902, p. vi, Liverpool School of Tropical Medicine, Memoir X).

*Phlebotomus* was taken on the walls of most of the Rest Houses; and as these walls are usually composed of swish mixed with a certain proportion of dung, they offer, when they become seamed with fissures, ideal breeding places for these insects. Possibly the washing of the mud walls of the Rest Houses with extract of "dawa-dawa" trees (*Parkia biglobosa*) has some efficacy in diminishing the breeding places of *Phlebotomus*, as it certainly seems to prevent the walls from cracking; washing with wood ash is not nearly so effectual. As *Phlebotomus* is not partial to light or breezes, this is the probable explanation of its rarity upon the walls of the Rest Houses in the Lorha District, which are the largest, best lighted and best ventilated of any in the Northern Territories.

Pappataci fever has been reported from Nigeria (Yellow Fever Commission Fourth and Final Report, pp. 13-17); it is almost certain that it also occurs in the Gold Coast.

*Culicoides* were taken in the evenings at several places and were felt and seen at others where they were not captured. Fortunately these little pests are less prevalent in the open country of the north than in the forest region of Ashanti. *Culicoides grahami*, Aust., which is the commonest species in Ashanti, is rare in the Northern Territories; it appears to be replaced by other larger species with less conspicuously spotted wings (*Forcipomyia*). Larvae and pupae of *Forcipomyia ingrami*, Cart., were found in the moist debris scraped from the "rot" holes in a flamboyant tree at Gambaga.

With reference to the greater prevalence of *S. fasciata* throughout the Northern Territories during and shortly after the close of the wet season, attention may be directed to the fact that all recent cases of yellow fever amongst Europeans resident

in the Northern Territories have occurred between July and the end of November, most of them indeed between September and the end of November.

It remains for me to express my indebtedness to the Hon. Principal Medical Officer for help rendered and interest shown in the work, and to thank Dr. Marshall, of the Imperial Bureau of Entomology, for kindly identifying certain of the mosquitos mentioned in the lists of the diary.

*Diary of Entomological Findings during the Tour.*

GOLD COAST COLONY.

- 15.iv.18. **Tafo.** *Culicoides ?grahami*, taken on arms in evening; *Phlebotomus* (*P. ?minutus* var. *africanus*, Newst.) seen on walls of Rest House.
- 16.iv.18. **Anyinam.** Heavy rain from 6-8.30 p.m. No mosquitos or sandflies in evidence.
- 17.iv.18. **Jyagate.** *Culicoides ?grahami* seen on arms.
- 18-19.iv.18. **Mpraesu.** No mosquitos or sandflies captured in District Commissioner's quarters. *Hippocentrum trimaculatum* very plentiful on the top of the Bauxite Hill.
- 20.iv.18. **Kwahu Prasu.** *Culicoides ?grahami* exceedingly troublesome; several taken. *Musca domestica* unpleasantly numerous. "Bush" too close to Rest House.

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- 21.iv.18. **Joasu.** *Culicoides ?grahami* taken.
- 22-30.iv.18. **Coomassie.** *Culicoides grahami* and *Forcipomyia* sp. taken. *Culicomyia nebulosa* taken in the Medical Officer's quarters.
- 1.v.18. **Jato's Zongo.** A few mosquitos biting, but none captured.
- 2.v.18. **Attabubu.** Many mosquitos biting, none captured.

NORTHERN TERRITORIES.

- 3.v.18. **Prang.** A few mosquitos heard, none taken; a Chironomid (? *Culicoides*) seen on walls of latrine.
- 4.v.18. **Kaperleum.** No roof to latrine; latrine bucket contained rain-water in which were larvae of *Culicomyia nebulosa*, also several egg-rafts of *Culex* on surface of water. Village about a mile from Rest House.
- 5-6.v.18. **Yeji.** Mosquitos seen emerging from an old water-hole (well) near boys' quarters; hole too deep to procure larvae. *Stegomyia vittata* larvae found in water contained in a disused canoe on the river bank. A fig tree close to the District Commissioner's quarters showed several "rot" holes.
- 7.v.18. **Macongo.** *Anopheles funestus* and *A. costalis* taken on walls of latrine; *Phlebotomus* sp. also taken on walls.
- 8-9.v.18. **Meriki's or Maliki's Zongo.** Native compounds visited. Larvae of *S. fasciata* found in a disused kettle. Larvae of *Culex duttoni* in a "fufu" mortar, larvae of *C. tigripes* var. *fuscus* and *C. invidiosus* found in a water-hole.



- 10-13.v.18. **Salaga.** *Phlebotomus* taken on walls of M. O.'s quarters. Larvae of *S. fasciata* found in calabashes. Larvae of *C. duttoni* and *C. decens* in a shallow water-hole in town. "Rot" holes seen in an akee tree (*Blighia sapida*), in a fig tree and in a silk-cotton tree (*Eriodendron anfractuosum*).
- 14.v.18. **Dogankade.** *Phlebotomus* sp. and *Forcipomyia* sp. taken in Rest House. Larvae of *C. duttoni*, *C. tigripes* var. *fuscus* and *S. vittata* breeding in a water-pot in the Rest House compound. Native compounds not visited.
- 15.v.18. **Turu.** *Phlebotomus* sp. on walls of Rest House; *Culicoides* sp. felt and seen. Larvae of *S. fasciata* and *C. invidiosus* found in a hole in a felled tree close to Rest House. A single specimen of *Tabanus subangustus*, Ric., taken.
- 16.v.18. **Palbe.** A few *Phlebotomus* sp. taken on walls of Rest House. No collections of water found in native compounds.
- 17-18.v.18. **Yamalaga.** *Phlebotomus* taken on walls of Rest House. No collections of water found in native compounds. "Rot" holes seen in a "dawa-dawa" tree (*Parkia*) close to the Rest House. The inhabitants of Palbe and Yamalaga at the present season have to go long distances for their water (2 miles?), consequently water is at a premium and none is left for mosquito larvae to breed in.
- 19-24.v.18. **Tamale.** Native town not visited, as the record of mosquitos occurring at this station due to the work of Dr. C. E. S. Watson and Dr. J. J. Simpson proves the presence of at least 15 species, amongst them *S. fasciata*. A "rot" hole in a flamboyant tree near the cemetery contained water in which larvae of *S. ?unilineata*, Theo., were breeding. No *Phlebotomus* or *Culicoides* seen or captured.
- 25.v.18. **Savelugu.** *Phlebotomus* on walls of Rest House. Larvae of mosquitos in pots and calabashes in nearly every compound inspected, the species being *C. duttoni*, *C. tigripes* var. *fuscus*, *C. decens*, *S. fasciata* and *S. vittata*. Larvae of *A. costalis* found in water-holes, which are numerous within 400 yards of the Rest House.
- 26.v.18. **Diari.** A single *Phlebotomus* taken on Rest House walls. Utensils in native compounds harbour larvae of *C. duttoni* and *C. tigripes* var. *fuscus*. Only three compounds visited, as an approaching tornado precluded further search.
- 27-29.v.18. **Nasia.** Larvae of *C. duttoni*, *C. decens* and of *S. fasciata* collected from utensils in native compounds. A single specimen of *Anopheles funestus* taken on the Rest House wall.
- 30.v.18. **Kpalgu.** *Phlebotomus* on walls of Rest House. Larvae of *C. duttoni*, *C. decens*, *Culicomyia nebulosa* and *S. fasciata* found in native compounds.
- 31.v.18. **Maibindiga.** *Phlebotomus* on walls of Rest House. Larvae of *C. duttoni* found in earthenware pots. No larvae of *Stegomyia* found.



- 1-5.vi.18. **Gambaga.** *Phlebotomus* on walls of latrine and on Rest House verandah; engorged *Phlebotomus* also taken within mosquito net. *C. duttoni*, *Culicomyia nebulosa* and *S. fasciata* bred out from larvae collected from the native compounds. Larvae of *C. ager* var. *ethiopicus*, *C. invidiosus*, *A. costalis* and *A. funestus*, found in off-sets of the stream running through the European garden. *S. vittata* found breeding in rock pools. "Rot" holes numerous in flamboyant and other trees near Rest House.
- 6.vi.18. **Zongoire.** A solitary *Phlebotomus* seen on the walls of the Rest House, but it eluded capture. Larvae of *C. duttoni*, *C. tigripes* var. *fuscus* and *Culicomyia nebulosa*, collected from native compounds. No *Stegomyia* larvae found.
- 7.vi.18. **Kugri.** No *Phlebotomus* seen. Larvae of *S. fasciata*, *C. duttoni*, *C. tigripes* and *C. invidiosus*, collected from utensils in native quarters.
- 8.vi.18. **Binduri.** No *Phlebotomus* seen; dry atmosphere, strong breeze prevalent. Larvae of *S. fasciata*, *C. duttoni*, *C. decens* and *Culicomyia nebulosa*, collected from native compounds. "Rot" holes in a tamarind and in an unknown tree close to Rest House.
- 9-12.vi.18. **Bawku.** *Phlebotomus* on walls of M.O.'s quarters; engorged *Phlebotomus* caught inside mosquito net. Town clean, very few pots or calabashes in native compounds in a position to hold water, most of them "up-ended." Larvae of *S. fasciata* found after diligent search; larvae of *C. duttoni* and *C. decens* rather more common. Larvae of *A. funestus*, *A. costalis*, *A. mauritanus*, *A. rufipes*, *C. ager* var. *ethiopicus*, *C. quasigelidus*, *C. invidiosus* and *Mimomyia mimomyiaformis*, Newst., collected from pools near garden and down course of main stream.
- 13.vi.18. **Tishi.** *Phlebotomus* on walls of Rest House. Larvae of *C. duttoni*, *C. tigripes*, *C. decens*, *Culicomyia nebulosa*, *S. fasciata* and *S. vittata*, collected from native compounds and surroundings.
- 14.vi.18. **Tili.** *Phlebotomus* taken on walls of Rest House. Larvae of *S. fasciata* and *C. duttoni* found in native compounds; village small, consisting of about five scattered compounds.
- 15.vi.18. **Nangudi.** *Phlebotomus* plentiful on Rest House walls. Larvae found in native compounds are those of *S. fasciata*, *S. vittata* and *C. duttoni*.
- 16-17.vi.18. **Zouragu.** *Phlebotomus* on walls of District Commissioner's quarters. In collections of water from the native compounds are larvae of *S. fasciata*, *S. vittata* and *C. decens*. Larvae of *C. invidiosus* and *A. costalis* collected from pots in European garden. In pools down course of stream (at present not flowing) larvae of *C. invidiosus*, *C. tritaeniorhynchus* and *A. costalis* found. "Rot" holes in several trees around District Commissioner's quarters.
- 18.vi.18. **Winduri (Tong Hills).** No *Phlebotomus* seen. Native compounds not visited. Larvae of *S. vittata* very numerous in rock pool and three larvae of *A. pretoriensis* collected from these pools. A large water-hole near Rest House had a few clumps of *Pistia stratiotes* growing in it, but the only larva collected from it was that of *Mimomyia splendens*, Theo.

- 20.vi.18. **Sambolugu.** No *Phlebotomus* found on walls of Rest House, walls treated with extract of "dawa-dawa." Larvae or pupae of *S. fasciata*, *S. vittata*, *C. duttoni*, *C. decens* and *C. tigripes* in water contained in earthenware pots in native compounds.
- 21.vi.18. **Mayoro.** Walls of Rest House washed with "dawa-dawa"; no *Phlebotomus* found. Earthenware pots in native compounds harboured larvae or pupae of *S. fasciata*, *S. vittata*, *C. decens* and *C. tigripes*.
- 22-25.vi.18. **Navarro.** *Phlebotomus* on walls of M.O.'s quarters. Collections of water in the native compounds furnished larvae of *C. decens*, *C. duttoni*, *C. tigripes* var. *fuscus*, *Culicomyia nebulosa* and *A. costalis*. Larvae of *S. fasciata* and *S. metallica* were found in a watering-pot beneath a large fig tree close to District Commissioner's quarters; this fig tree showed numerous rot holes in roots, which had been filled by rain on 22.vi.18; no larvae appeared in these holes during the ensuing three days. No "resistant" eggs present? *S. fasciata* taken on arm in M.O.'s quarters at 4 p.m., 25.vi.18. Larvae of the following mosquitos collected in pools along course of stream (not flowing at present) *C. ager* var. *ethiopicus*, *C. quasigelidus*, *C. invidiosus*, *C. univittatus*, *Ochlerotatus caliginosus*, Graham, *A. costalis*, *A. funestus* and *A. mauritanus*.
- 26.vi.18. **Tiana.** No *Phlebotomus* found on walls of Rest House, which were treated with "dawa-dawa." Earthenware pots in native compounds contained larvae of *C. decens*, *C. tigripes* (killed to prevent their devouring the other larvae), *Culicomyia nebulosa* and *S. fasciata*.
- 27-28.vi.18. **Nacon.** No *Phlebotomus* taken; inside walls of Rest House show ornamental designs, but are not treated with "dawa dawa"; double doors and large windows (27" × 27"), room well ventilated and well lighted. Larvae of *S. vittata* numerous in rock pools, borrow-pits and earthenware pots. *S. fasciata* larvae in small collections of clean water in native compounds. *Culicoides* felt and seen but not captured.
- 29.vi.18. **Batiasan.** No *Phlebotomus* found; walls of Rest House not treated in any way, but a breeze blowing. Nearest native compound at least  $\frac{1}{4}$  mile distant from Rest House. Larvae of *C. duttoni*, *C. decens*, *C. tigripes* (killed to prevent devouring the other larvae) and *S. fasciata*, in pots in native compounds. *S. vittata* breeding in small collections of water provided for hens.
- 30.vi.18. **Pinna.** *Culicoides* seen on arm about 4 miles on the Batiasan side of Pinna. No *Phlebotomus* taken on walls of Rest House; walls untreated, but showed no cracks. Usual series of larvae collected in native compounds, namely of *C. duttoni*, *C. decens*, *S. fasciata* and *S. vittata*.
- 1-3.vii.18. **Tumu.** *Culicoides* felt and seen, but none captured. No *Phlebotomus* found. Larvae or pupae of *C. duttoni*, *C. tigripes* var. *fuscus*, *Culicomyia nebulosa*, *S. fasciata* and *S. vittata*, breeding in native compounds. Larvae of *C. duttoni* found breeding in a pool in swamp where utensils

which had contained "peto" are washed. Larvae of *A. costalis* collected from foot-prints of cattle at the edge of the swamp. In the swamp larvae of *A. funestus*, *A. mauritanus* and *C. invidiosus* discovered; also an unknown pupa with deeply infuscated paddles (this pupa died). Swamp pools contained very few larvae, having recently been filled with storm water.

- 4.vii.18. **Lilixia.** *Phlebotomus* on walls of Rest House; walls washed with wood ash. Larvae of *S. vittata* found in a portion of a calabash in the Rest House compound. In the native compound several egg-rafts of Culicine mosquitos (probably *Culex duttoni* and *Culicomyia nebulosa*) were seen, but the only larvae collected were those of *C. tigripes* var. *fuscus*. "Rot" holes were visible in the roots and trunk of two "dawa-dawa" trees in the Rest House compound.
- 5.vii.18. **Jefisi.** No *Phlebotomus* taken; walls of Rest House treated with wood ash. Earthenware pots in the compounds of the native huts contained larvae of *Culicomyia nebulosa*, *C. duttoni*, *C. decens*, *S. fasciata* and *S. vittata*. Rest House well lighted on western side with good air space between roof and wall.
- 6.vii.18. **Nandaw.** No *Phlebotomus* taken; walls of Rest House untreated, but room airy, with ample window accomodation and good air space between roof and wall. Larvae of *C. duttoni*, *C. decens*, *Culicomyia nebulosa*, *S. fasciata* and *S. vittata* in native compounds.
- 7.vii.18. **Ulu.** No *Phlebotomus* found. *Culicoides* taken on arm. Collections of water in native compounds contained larvae of *C. duttoni*, *C. decens*, *Culicomyia nebulosa* and *S. fasciata*. Larvae of *S. vittata* and *Ochlerotatus nigeriensis*, Theo., in small pools near native huts.
- 8.vii.18. **Daweni.** No *Phlebotomus* taken. Larvae and pupae of *C. duttoni* and *C. tigripes* var. *fuscus* and larvae of *C. decens* found in pots in native compounds. Larvae of *Culicomyia nebulosa* found in a disused "fufu" mortar some distance away from village.
- 9-12.vii.18. **Lorha.** No *Phlebotomus* taken. Calabashes and pots in native quarters contained larvae of *C. decens*, *Culicomyia nebulosa* and *A. costalis*. Larvae of *A. funestus*, *A. mauritanus*, *C. invidiosus*, *C. ager* var. *ethiopicus* and *C. quasigelidus*, and a pupa of *Mimomyia mimomyiaformis* found in pools below the European garden. "Crocodile" pool and an adjacent pool covered with *Pistia stratiotes*; larvae of *Mansonioides* collected from the roots, but unfortunately died, so that species could not be determined. It remains to be discovered if the larva of *M. uniformis*, Theo., differs in detail from that of *M. africanus*, Theo. *M. uniformis*, but not *M. africanus*, has been recorded from this station and from Wa. Dr. Corson while resident at this station made a collection of mosquitos (determined by Mr. Carter of Liverpool) containing 13 different species, including *S. fasciata*.
- 13.vii.18. **Burifu.** No *Phlebotomus* taken. Native compounds not visited. Larvae of *A. costalis* found in swamp.

- 14.vii.18. **Yawa or Yaga.** No *Phlebotomus* taken. Larvae of *Culiciumyia nebulosa* discovered in an earthen pot in Rest House yard. Larvae of *Culiciumyia nebulosa*, *C. duttoni*, *C. decens*, *C. tigripes* var. *fuscus* and *S. fasciata*, collected from native compounds. Almost all the larvae were devoured by the larvae of *C. tigripes* in the course of the next two days.
- 15.vii.18. **Nandawli.** *Phlebotomus* taken on walls of Rest House, which is not of the "Lorha" type; individual houses close together, yard divided by retaining walls, ventilation impeded. The usual species of mosquito larvae found in native quarters, namely *C. duttoni*, *C. decens*, *C. tigripes* var. *fuscus*, *S. fasciata* and *S. vittata*.
- 16.vii.18. **Kalleo.** No *Phlebotomus* taken; walls of Rest House untreated, but plenty of window accomodation and two doors giving a thorough draught. Larvae of *S. fasciata*, *C. duttoni*, *C. decens* and *C. tigripes* in pots in native quarters.
- 17-20.vii.18. **Wa.** *Phlebotomus* found on walls of Rest House. Larvae or pupae of *C. duttoni*, *C. tigripes* var. *fuscus*, *C. decens* and *S. fasciata* secured from earthen pots in native compounds. Larvae or pupae of *C. ager* var. *ethiopicus*, *C. invidiosus*, *A. costalis*, *A. funestus*, *A. mauritanus* and *Mimomyia mimomyiaformis*, in pools near garden. One or two larvae of *Mansonioides* (these pupated but died as pupae) taken from roots of *Pistia stratiotes* growing on surface of "Crocodile" pool. Dr. Corson formed a collection of 11 species of mosquitos while resident in Wa in 1914.
- 21.vii.18. **Tanina.** No *Phlebotomus* found in Rest House. *C. duttoni*, *C. decens*, *S. fasciata* and *S. vittata*, found in larval form in native compounds. *Culicoides* abundant.
- 22.vii.18. **Kulmasa.** *Phlebotomus* (scarce) found on walls of Rest House. Larvae of *C. duttoni*, *S. fasciata* and *S. vittata* taken from collections of water in the native compounds. *Culicoides* taken.
- 23.vii.18. **Tuna.** No *Phlebotomus* found; walls of Rest House showed no cracks. *Culicoides* taken. Larvae of *C. duttoni* and *Culiciumyia nebulosa* discovered in earthen pots in native quarters. No larvae of *S. fasciata* seen.
- 24.vii.18. **Mankoma.** No *Phlebotomus* taken. Larvae of *C. duttoni*, *C. tigripes* var. *fuscus*, *Culiciumyia nebulosa* and *S. fasciata*, found in water vessels in native compounds. *Culicoides* taken.
- 25.vii.18. **Bole.** *Phlebotomus* found on walls of District Commissioner's quarters. Native compounds not visited, nor any active search made for larvae of mosquitos, as a collection of the mosquitos of this station, numbering thirty species, was made in 1911-1912 by myself. *S. fasciata* was included in that collection. An unknown larva with basal hair tufts on its siphon tube was taken in one of the large borrow-pits, but unfortunately died "en route." *Culicoides* taken (probably *Forcipomyia incomptifemini* Aust., which was taken here in 1912).



- 28.vii.18. **Sakpa.** No *Phlebotomus* taken. *Glossina palpalis*, R.D., and *Glossina morsitans*, Westw. (*submorsitans*, Newst.) taken in Rest House. Larvae of *C. tigripes* var. *fuscus* and *Culiciomyia nebulosa* found in native compounds. No *S. fasciata* larvae seen. *Culicoides* taken. *G. morsitans* taken on road between Suripe and Sakpa. *G. palpalis* taken on arm in Suripe swamp.
- 29.vii.18. **Malowe.** Numerous *G. morsitans* on road from Sakpa. *Phlebotomus* on walls of Rest House. *S. fasciata*, *C. tigripes* var. *fuscus* and *Culiciomyia nebulosa*, found as larvae in native compounds. *Culicoides* taken.
- 30.vii.18. **Banda Nkwanta.** *G. morsitans* on road between Malowe and Wasipe fairly numerous, scarce on road between Wasipe and Banda Nkwanta. *Phlebotomus* found on walls of Rest House. Larvae of *C. duttoni*, *C. tigripes* var. *fuscus*, *S. fasciata* and *Culiciomyia nebulosa*, in earthen pots in native quarters. *Culicoides* numerous.
- 1.viii.18. **Jugbe.** *Phlebotomus* taken on Rest House walls. Collections of water in native compounds contained larvae of *C. duttoni*, *C. tigripes* var. *fuscus* and *Culiciomyia nebulosa*. No *Stegomyia* larvae seen. *Culicoides* taken.

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- 2.viii.18. **Buere.** Mosquito larvae not searched for. *Culicoides* taken.
- 3-5.viii.18. **Kintampo.** Several flamboyant trees on side of road from Provincial Commissioner's bungalow to Court House showed "rot" holes, in one of which larvae of *Culiciomyia nebulosa* were found. *Phlebotomus* previously recorded here, also *S. fasciata*.
- 6.viii.18. **Kukuma.** *Phlebotomus* on walls of the Rest House. A single specimen of *Mansonoides africanus* seen entangled in a spider's web in Rest House. *Culicoides* taken.
- 7.viii.18. **Nkoranza.** *Phlebotomus* (previously recorded from this place) on walls of Rest House.
- 8.viii.18. **Sevodumase.** *Phlebotomus* (previously recorded from this place) on walls of Rest House. *Culicoides*? *grahami* taken.
- 9.viii.18. **Chechewere.** *Phlebotomus* on walls of Rest House. *Culicoides grahami* numerous.
- 10.viii.18. **Kwaman.** *Phlebotomus* on walls of Rest House. *Culicoides grahami* exceedingly numerous.

## THE EARLY STAGES OF WEST AFRICAN MOSQUITOS—IV.

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In three previous papers (Bull. Ent. Res. vii, pp. 1-18; viii, pp. 73-91; and viii, pp. 135-154) we have described early stages of a number of West African mosquitos collected at Accra and at other places in the Gold Coast. The present paper deals with a few more early stages of mosquitos, for the most part collected by one of us (A.I.) in the Northern Territories of the Gold Coast, and thus fills in a gap or two in the knowledge of the life-histories of these insects.

The majority of the descriptions which follow are of pupae. As in our previous paper we have taken for diagnostic purposes more particularly the characters of the paddles, and the hairs or setae at the posterior angles and on the dorsal aspect of the abdominal segments. On the dorsal aspect and at the posterior margins of the segments of the abdomen there are important hairs which form two distinct rows on each side of the body from usually the 3rd to the 7th segments. The one row is situated midway between the posterior angles and the middle line of the body, the other about midway between the posterior angles and the first row. These two rows of hairs do not appear to have received names, we therefore propose to call them respectively the "inner and outer lateral rows."

We have found it advisable to introduce into the descriptions of pupae certain ratios, such as the ratio of length to greatest breadth of the paddles or respiratory trumpets. The respiratory trumpet is composed of two parts, a closed or tubular part which is proximal, and an open part which is distal; the former we propose to call the meatus, and the latter the pinna. The relative length of the meatus varies greatly in different species of mosquito, and this fact we think may be most accurately expressed as the ratio of the length of the meatus to the total length of the respiratory trumpet.

**Anopheles pretoriensis**, Theo.

LARVA.—The larva of this mosquito is included by Edwards (Bull. Ent. Res. iii, p. 374) in his key to the larvae of the genus *Anopheles*.

PUPA (fig. 1).—The pupa is small, measuring about 4 mm. when extended, and feebly chitinated.

The paddles, which are about 7 mm. long, are oval, the ratio of length to greatest breadth being about 1.6 to 1; they are furnished with a midrib, and an external buttress which does not seem to extend beyond the proximal third of the blade. The hook-shaped hair on the distal edge of the paddle is well developed and about half the length of the paddle; proximal to it, near the end of the midrib, is a short straight hair which is forked almost from its base, and is about one-sixth the length of the hook-shaped hair. The paddles carry a fringe of rather delicate hairs, longest on the distal border; this fringe appears to begin at a point beyond the middle of the external border.

At the posterior angle of the 8th abdominal segment is a stout seta giving off a number of branches; it is about one-quarter the length of the paddle, and its spread of branches is only moderate.

At the posterior angles of the 7th, 6th and 5th segments are long spines, curved and sharply pointed; on the 4th and 3rd segments the corresponding spines are short and blunter: and on the 2nd segment very small and feebly chitinised.

In addition to the spines already described there are numerous hairs on the body of the pupa, the most important being those on the dorsal aspect at the posterior margins of the 3rd to the 7th segments which are arranged in two rows on each side of the abdomen. The hairs of the one row, the outer lateral row, are situated a little internal to the angle; they are branched. The hairs of the other row, the inner lateral row, are situated about mid-way between the posterior angle and the middle line; they are long single hairs on the 7th, 6th and 5th segments, and branched hairs similar to those in the outer lateral row on the 4th and 3rd segments. The dendritic hairs on the 1st segment are well developed.

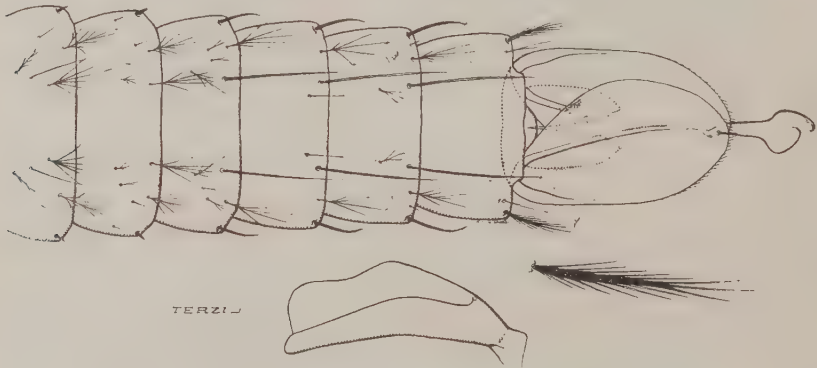


Fig. 1. Pupa of *Anopheles pretoriensis*, Theo.

The respiratory trumpets are about 4 mm. long; they are, as usual, composed of two parts, a closed part or meatus which is proximal, and an open part or pinna which is distal. In the pupa of *A. pretoriensis* the meatus is short; the ratio of its length to the total length of the trumpet being about 1 to 3. The pinna as it expands forms a slight angle a little beyond the distal margin of the meatus; this angle is much less acute than that shown by *A. costalis*.

*Diagnosis.*—The pupa of *A. pretoriensis* has to be separated from the other known pupae of this genus which have long, sharp and usually curved spines at the posterior angles of the 7th, 6th and 5th segments, that is, from those of *A. costalis*, *A. funestus*, *A. marshalli* and *A. pharoensis*. *A. costalis* is distinguished by having on the paddle a well developed buttress and a fringe which begins at a point proximal to the middle of the external border, and by the characters of the respiratory trumpet to which reference has already been made; *A. funestus* by having a spine of considerable size at the posterior angle of the 4th segment, and by hairs in the inner lateral row on the 7th, 6th and 5th segments, which are often sub-divided; *A. marshalli* (if the specimen examined by us was typical) by

having a curved, but not hook-shaped hair at the end of the paddle, and by the hairs in the inner lateral row on the 7th, 6th and 5th segments, which are often subdivided; and *A. pharoensis* by the large hair on the end of the paddle not being hook-shaped.

*Habitat*.—The larvae of this mosquito were captured in shallow pools in outcrops of quartzite at Winduri, Tong Hills, in the Northern Territories of the Gold Coast, 18.vi.1918. They were associated with larvae of *Stegomyia vittata*, Bigot (*sugens*, Theo., *nec* Wied.).

***Anopheles rufipes*, Gough.**

*LARVA*.—The larva of this mosquito is included by Edwards (*loc. cit.*, p. 374) in his key to the larvae of African species of the genus *Anopheles*.

*PUPA* (fig. 2).—The pupa is small, measuring about 3.5 to 4 mm. when extended, and very strongly chitinised.

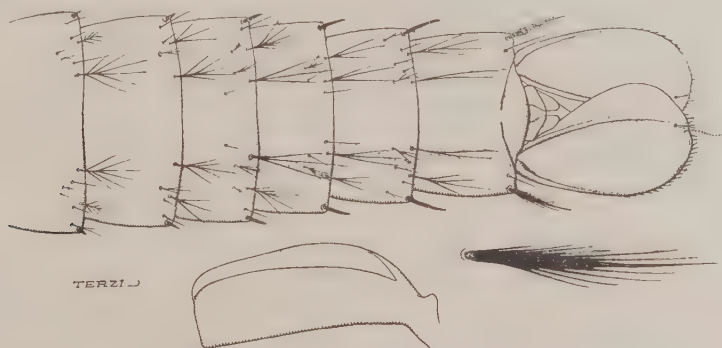


Fig. 2. Pupa of *Anopheles rufipes*, Gough.

The paddles, which are about .6 mm. long, are oval, the ratio of length to greatest breadth being about 1.5 to 1; they are supported by a well-developed midrib and an external buttress, which is not so well developed as that of *A. costalis*. The hair on the distal edge of the paddle, which in some other species resembles a boot-hook, is unfortunately missing from the two pupae examined. On each paddle, near the end of the midrib, there is a short hair divided towards its tip. This splitting towards their tips of the small hairs of the paddles is not a character of specific importance, as it occurs occasionally in *A. costalis*. The paddle bears a fringe which begins at a point a little proximal to the middle of the external border.

At the posterior angle of the 8th abdominal segment is a stout seta giving off branches, which resembles the corresponding seta of the pupa of *A. funestus*; it measures about one-quarter the length of the paddle.

At the posterior angle of the 7th segment is a curved and pointed spine; on the 6th, 5th and 4th segments the corresponding spines are straight and shorter. These angle spines are smaller the more anterior the segment to which they are attached; those on the 3rd and 2nd segments being minute.

In addition to the spines already described there are numerous hairs on the body of the pupa, especially along the posterior margins of the segments; the



most important are those which form the outer and inner lateral rows on each side on the dorsum of the abdomen. The hairs forming the outer lateral row are branched. Those forming the inner lateral row are long single, double, or triple hairs on the 7th, 6th and 5th segments, and branched hairs, similar to those in the outer lateral row, on the 4th and 3rd segments. The dendritic hairs or tufts on the 1st segment are well developed.

The respiratory trumpets are about .36 mm. long; the pinna, the open part, extends nearly the whole length of the trumpet, the ratio of the length of the closed portion, the meatus, to the total length of the trumpet being nearly 1 to 5. There does not appear to be any angle formed by the pinna a little above the distal margin of the meatus, such as there is in *A. costalis*.

*Diagnosis.*—The pupa of *A. rufipes* has to be distinguished from that of *A. mauritianus* (neither having long sharp spines at the posterior angles of the 7th, 6th and 5th segments), and this may be done by the spine at the posterior angle of the 7th segment, which is long and curved in *A. rufipes*, but short and straight in *A. mauritianus*. The harp-shaped form of the dendritic seta on the 8th segment of *A. mauritianus* is not a good character, as it is inconstant.

*Habitat.*—The two pupae on which the above description is based were found in pools of clear water collected in the dry bed of a stream near the garden at Bawku in the Northern Territories of the Gold Coast, 11.vi.18. With them were associated pupae of *A. funestus*.

### ***Ochlerotatus hirsutus*, Theo.**

LARVA. The larva of this mosquito has not yet been identified.

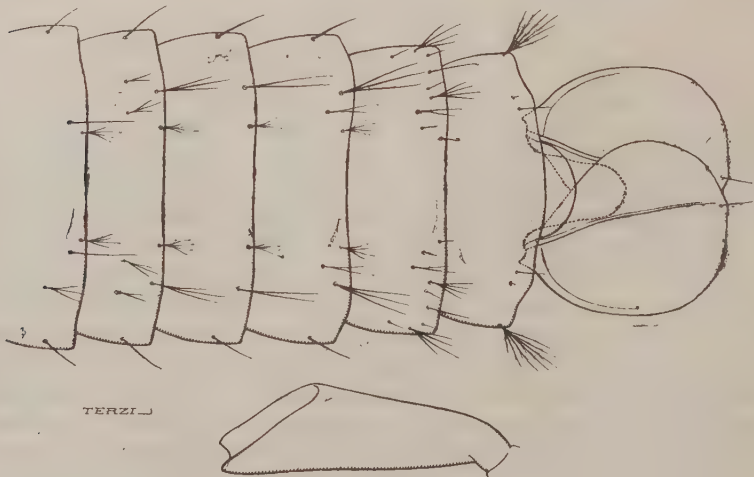


Fig. 3. Pupa of *Ochlerotatus hirsutus*, Theo.

PUPA (fig. 3).—The pupa is large, measuring about 6 to 7 mm. when extended, and well chitinated.

The paddles, which are about 1 mm. long, are broad, the ratio of length to greatest breadth being about 1·2 to 1; they are supported by an external buttress and a moderately well developed midrib. At the end of the midrib is the usual long single hair, which is about one-eighth the length of the paddle. The paddles are devoid of a fringe.

At the posterior angle of the 8th abdominal segment is a tuft of 7 to 8 subplumose hairs, of which one or two may be branched. This tuft is short, about one-fifth the length of the paddle.

A little above the posterior angle of the 7th segment is a tuft of 3 or 4 pubescent hairs; this tuft is about one-sixth the length of the paddle. In a similar position on the 6th, 5th and 4th segments there is a single hair, sometimes divided.

In addition to the tufts and hairs, already described, there are on the dorsal aspect of the abdomen numerous small and delicate hairs, most of which are quite inconspicuous; those situated in the positions corresponding to the outer lateral row on the 4th to the 6th segments are, however, better developed, and are long double or triple hairs. On the same segments in the positions corresponding to the inner lateral row are small tufts of delicate hairs. The hairs on the posterior margins of the 7th segment are all small. On the posterior margin of the 3rd segment is a small tuft in line with the inner lateral row, and a single hair of moderate length a little above and external to it. The dendritic hairs or tufts on the 1st and 2nd segments are moderately well developed.

The respiratory trumpets are about 7 mm. long; they are rather broad, and have wide apertures. The ratio of the length of the closed portion, the meatus, to the total length of the trumpet is about 1 to 1·5.

*Diagnosis*.—See *O. nigeriensis* (p. —).

*Habitat*.—The two pupae on which the above description is based were found in a collection of rain-water in a disused kerosene tin at Accra, Gold Coast, 11.xii.17. The tin was partly concealed by vegetation.

### ***Ochlerotatus nigeriensis*, Theo.**

*LARVA*.—The larva of this mosquito is included by Edwards in his "Revised Keys to the Known Larvae of African Culicinae" (loc.cit., pp. 376 and 377), and is figured by him.

*PUPA* (fig. 4).—The pupa is of moderate size, measuring about 5 to 6 mm. when extended, and is very strongly chitinised.

The paddles, which are nearly 1 mm. long, are broad, the ratio of length to greatest breadth being about 1·2 to 1; they are supported by a midrib and by an external buttress, which, however, is not conspicuous. Near the end of the midrib is the usual long single hair, measuring in this species about one-eighth the length of the paddle. The paddles have no fringe, but may show a few minute teeth, especially about the middle of the external border; these teeth are too inconspicuous to show in the figure.

At the posterior angle of the 8th abdominal segment is a tuft of about six (5 to 7) hairs which are subplumose at their bases and sometimes branched towards their tips. This tuft is short, its length being about one-fifth the length of the paddle.

Near the posterior angle of the 7th segment is a tuft of three or four (2 to 5) hairs which are subplumose towards their tips. This tuft is a little shorter than the tuft on the 8th segment, measuring about one-sixth or one-seventh the length of the paddle. Near the posterior angles of the segments anterior to the 7th there are, as a rule, single hairs, occasionally double hairs.

In addition to the tufts and hairs already described, there are on the dorsal aspect of the abdominal segments a number of other hairs which are for the most part feebly developed; the most notable are those occupying positions corresponding to the hairs of the outer lateral row, which on the 4th to the 6th segments are long and usually single or double. The hairs corresponding to those of the inner lateral row on the 4th to the 6th segments are quite insignificant tufts or hairs; a similar tuft is present on the 3rd segment, with a single hair of moderate length above and a little external to it. The dendritic hairs or tufts on the 1st and 2nd segments are rather feebly developed, those on the 2nd segment being small and poorly chitinised.

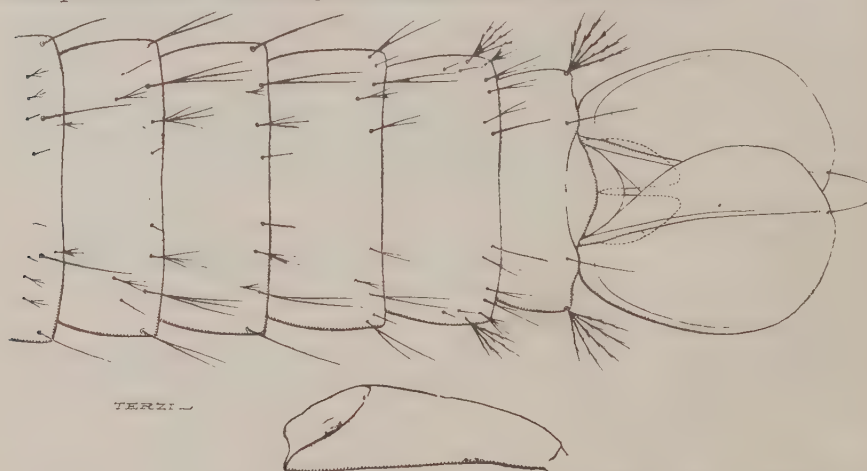


Fig. 4. Pupa of *Ochlerotatus nigeriensis*, Theo.

The respiratory trumpets are about 6 mm. long; they have wide mouths. The ratio of the length of the closed portion, the meatus, to the total length of the trumpet is about 1 to 1.5.

**Diagnosis.**—The pupa of *O. nigeriensis* resembles very closely that of the preceeding species, *O. hirsutus*, and both fall into the group in our key which includes *O. minutus*, *O. punctothoracis*, and *O. caliginosus*, species hitherto described in insufficient detail to be differentiated. *O. nigeriensis* may show a few minute teeth on the external border of the paddle which might be regarded as a fringe, but the tufts at the posterior angles of the 8th and 7th segments are sufficient to separate this species from *O. albocephalus*. No very satisfactory means has been found for distinguishing the pupae of *O. hirsutus* and *O. nigeriensis*, but perhaps the hairs of the inner lateral row on the 7th and 6th segments would serve, although they are inconspicuous.

**Habitat.**—The pupae of this mosquito were found in a borrow-pit containing slightly muddy water outside the village of Ulu, Lorha District, Northern Territories of the Gold Coast, 7.vii.1918.

***Culex ager*, Giles, var. *ethiopicus*, Edw.**

LARVA.—The larva of this mosquito has been figured by Edwards (loc. cit., p. 380) and has been included by him in his "Revised Keys to the Known Larvae of African Culicinae." One feature, however, which is not referred to by him and which is not shown in the figures, may be mentioned because it is unusual, that is, the shape of the mental plate. In the larva of *C. ager* var. *ethiopicus* this structure is shaped like an equilateral triangle, and its margin when viewed at a moderate magnification ( $1/6$  objective and No. 3 ocular) appears to be crenated but devoid of teeth (fig. 5, *a*); when examined with higher powers, however, the crenated margin is seen to be composed of a large number (about 60) of minute teeth, which increase in size slightly as they recede from the apex.

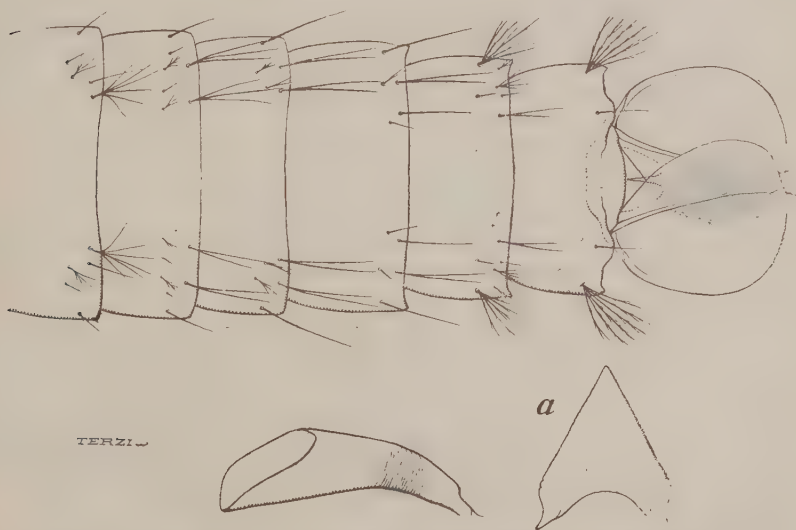


Fig. 5. Pupa of *Culex ager* var. *ethiopicus*, Edw.; *a*, mental plate of larva.

PUPA (fig. 5).—The pupa is large, measuring about 6 mm. when extended, and well chitinised, the sockets of the hairs, even minute ones, being marked by a thickened darkened ring. The paddles are infuscated. The trumpets have wide apertures, which are directed anteriorly in the living pupa.

The paddles, which are nearly 1 mm. long, are broad, the ratio of length to greatest breadth being about 1.1 to 1; they are supported by an external buttress and a well developed midrib. Near the distal end of the midrib are two minute hairs, the one considerably larger than the other; the larger hair is sometimes divided towards its tip. The paddle is infuscated at its distal end and over almost the whole of the inner lobe, and has no fringe.

At the posterior angle of the 8th abdominal segment is a tuft of 5 to 7 subplumose hairs, which are usually branched. This tuft is about one-quarter the length of the paddle.



A little above the posterior angle of the 7th segment is a tuft of 3 to 6 subplumose or pubescent hairs, which are usually branched. This tuft is almost as long as the one on the 8th segment, measuring about one-quarter the length of the paddle. Near the angles of the segments anterior to the 7th are single hairs, those on the 6th and 5th segments being strongly developed and the others more feebly.

Of the other hairs on the abdominal segments the most important are those forming the inner and outer lateral rows. On the 4th to the 6th segments the hairs in both these rows are long single, double, or triple hairs, those on the more anterior segments being usually but not invariably more sub-divided than those on the more posterior segments: on the 7th segment the hair belonging to the outer lateral row is small, that belonging to the inner lateral row a small double or single hair. These hairs, which are rather variable, are shown in the figure; it will be observed that they differ from the corresponding hairs of the pupa of *C. quasigehidus*. On the 3rd segment the most conspicuous hairs are a small tuft in line with the inner lateral row, a single hair above and a little external to this tuft, and a second small tuft above and external to the single hair. The dendritic hairs or tufts on the 1st segment are fairly well developed and have about 8 or 9 primary branches.

The respiratory trumpets are long, averaging nearly 1 mm. in length, and have wide apertures. The ratio of the length of the closed part of the tube, the meatus, to the total length of the trumpet is about 1 to 1.7.

*Diagnosis*.—This pupa may readily be distinguished from the pupa of *C. quasigehidus* (see p. 67), the only other *Culex* (*sens. str.*) pupa known to have infuscated paddles, as follows.

	<i>C. ager</i> var. <i>ethiopicus</i> .	<i>C. quasigehidus</i> .
Paddles.	Infuscation most notable on the inner blade, and extending almost to the base on this blade.	Infuscation not extending more than half way down the paddle at any point.
Tuft at the posterior angle of 8th segment.	8-9 hairs.	5-7 hairs.
Hairs at the posterior angles of 6th and 5th segments.	Single.	Triple or quadruple.
Trumpets.	Not unusually narrow, wide-mouthed.	Very long and narrow.

*Habitat*.—Larvae and pupae of this mosquito were found during June and July in swamps or in pools of clear water containing algae (*Spirogyra*) at many places in the Northern Territories of the Gold Coast, *e.g.*, at Gambaga, Bawku, Navara, Tumu, Wa, Bole, etc.

### ***Culex quasigehidus*, Theo.**

*LARVA*.—The larva of this mosquito has been described by Wesché (Bull. Ent. Res. i, pp. 38 and 39), and Edwards (*loc. cit.*, p. 383) has noted some age differences. Two fully developed larvae examined by us showed the following characters, which supplement the previous description: the mental plate small and composed of a median tooth with about six (5 to 6) teeth on each side; the comb of about six (6 to 7)

teeth arranged in a single row or in two short rows; the pecten of about nine (8 to 10) teeth; and the hairs on the dorsal border of the anal segment a fan-like arrangement of about five hairs above and a long hair below on each side.

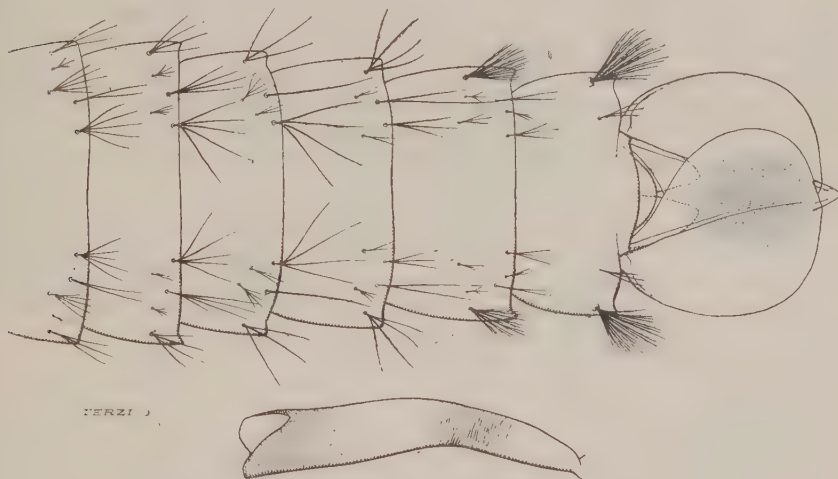


Fig. 6. Pupa of *Culex quasigelidus*, Theo.

**PUPA** (fig. 6).—The pupa of *C. quasigelidus* has been described very briefly by Wesché (loc.cit., p. 39), with figures of the respiratory trumpet and of the terminal segments of the abdomen. So long as this *Culex* pupa was unique in having a "distinct dark cloud" on the paddle Wesché's description sufficed for identification, but as the pupa of *C. ager* var. *ethiopicus* (see p. 66) has also an area of infuscation on the paddle it is now necessary to amplify the earlier description. The pupa is of medium size, measuring about 5 mm. when extended, and is well chitinised.

The paddles, which are about 8 mm. long, are broad, the ratio of length to greatest breadth being about 1.1 to 1; they are supported by a well developed midrib and an external buttress. Near the end of the midrib are two small hairs, the one larger than the other; the larger hair, which measures only about one-twelfth the length of the paddle, is sometimes divided towards its tip. There is a patch of infuscation at the distal end of the paddle which involves both the inner and outer lobes but does not extend far down towards the insertion of the paddle. There is no fringe on the paddles.

At the posterior angle of the 8th abdominal segment is a tuft of 8 or 9 subplumose hairs, which are also branched. This tuft is about one-quarter the length of the paddle.

Near the posterior angle of the 7th segment is a tuft of 4 or 5 subplumose hairs, which are also branched. This tuft is almost as long as the one on the 8th segment, measuring about one-quarter the length of the paddle. Near the posterior angles of each of the anterior segments, the 6th, 5th, 4th, and 3rd, is a delicate tuft of 3 or 4 hairs.

Of the other hairs on the abdominal segments the most important are those forming the inner and outer lateral rows. The outer lateral row is composed of a minute divided hair on the 7th segment, a long single or double hair on the 6th and 5th segments, and a tuft of three or more hairs on the 4th segment. The inner lateral row on the 7th to the 4th segments is composed of tufts which are larger in the more anterior segments. These rows are shown in the figure. On the 3rd segment the most conspicuous hairs are a tuft in line with the inner lateral row, a double hair above and a little external to this tuft, and another tuft above and external to the double hair. The dendritic hairs or tufts on the 1st segment are well developed and have about a dozen primary branches.

The respiratory trumpets are long and narrow, about .9 mm. in length. The ratio of length to greatest breadth is, in a mounted specimen, 5 to 1. The trumpet is banded, the proximal end being pale and the distal end dark, and the middle zone is divided into two portions, the upper being pale and the lower dark. The ratio of the length of the closed portion, the meatus, to the total length of the trumpet is about 1 to 1.16, that is the meatus is very long.

*Diagnosis*.—See *Culex ager* var. *ethiopicus* (p. 66).

### **Culex univittatus**, Theo.

LARVA (fig. 7).—The head is large, nearly as wide as the thorax. The brushes are well developed. The antenna is dark and covered with prominent spicules, the hair-tuft being situated just before the middle point of the shaft. The mid-frontal hairs are multiple, the constituent hairs being lightly subplumose; the ante-antennal tuft is also composed of lightly subplumose hairs. The mental plate is triangular in shape; it has a central tooth with about ten to twelve teeth on each side, the lateral teeth being small, but gradually increasing in size towards the base of the plate.

The thoracic plumes, which are formed of subplumose hairs, are well developed.

The lateral abdominal hairs are multiple on the first two segments, triple on the third segment, and thereafter single on each segment.

All the plumes on the 8th abdominal segment are formed of simple or only slightly subplumose hairs. The comb consists of about 8 spines arranged irregularly. The siphon is about seven or eight times as long as its width at the basal ring, and tapers regularly from base to apex. The pecten extends about two-fifths of the length of the siphon from the basal ring; it consists of 13 to 16 teeth of which the two or three furthest from the base are more detached and have no secondary spines. There is a slight tuft of a few simple hairs some distance beyond the last tooth of the pecten, namely, at a point about three-quarters of the length of the siphon from its base.

The anal segment carries very long papillae, three times the length of the segment, the dorsal pair being slightly longer than the ventral. The beard is well developed. The hairs on the dorsal end of the segment are peculiar, consisting of a fan-like collection of 8 or 9 hairs above and an extremely long hair below on each side. The long hairs are nearly twice as long as the anal papillae.

*Diagnosis*.—Edwards includes the larva of this mosquito in his key to the larvae of the genus *Culex* (Bull. Ent. Res. iii, p. 381), but states that there are six teeth in the pecten, whereas our specimens had 13 to 16. This discrepancy does not, however,

confuse the identification of this species or its differentiation from those whose larvae have a siphon about half as long as the abdomen.



Fig. 7. Head and terminal segments of larva of *Culex univittatus*; a, mental plate.

*Habitat.*—The larvae of this mosquito were found in a grass-grown pool containing clear water at the edge of a swamp at Navaro, Northern Territories of the Gold Coast, 23.vi.18.





## TSETSE FLY IN SOUTHERN RHODESIA, 1918.

By RUPERT W. JACK, F.E.S.,

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(PLATES II-IV, MAPS I-III.)

The history of tsetse-fly in Southern Rhodesia up to the present year (1918) continues on the whole to be one of expansion, although on the other hand one small, but important, belt appears to have become extinct. In addition, a fly area in the Mozambique Company's territory has extended up to our eastern border, with the result that serious losses of cattle from trypanosomiasis have occurred on the farms in that region. Detailed reports on the advance or retrogression of *Glossina morsitans* in other parts of Africa appear to be lacking, and it is felt that in view of the position of this territory in relation to tsetse-fly a review of the situation to the present day may not be without general interest.

The "fly areas" in Southern Rhodesia may be referred to as follows:—

(1) Sebungwe Belt, occupying the greater portion of the western half of the Sebungwe district; (2) Umniati Belt, lying astride the Umniati river, partly in the Hartley and partly in the Sebungwe districts; (3) Northern Belt, occupying the greater part of the country between the escarpment and the Zambesi River in the northern portion of the Lomagundi district, and extending eastward into the Darwin district; (4) Jetjenini Belt, in the neighbourhood of Jetjenini Mountain, Lomagundi district; (5) Suri-suri Belt, in the vicinity of the Suri-suri river, between Hartley and Gatooma, in the Hartley district; (6) Melsetter Border Belt, lying almost entirely in Portuguese East Africa, but affecting certain farms on the eastern border of the Melsetter district.

(1) *Sebungwe Belt*. Owing to its extent and the fact that sleeping sickness is endemic in a certain portion of it, this is at present the most important fly-area in the territory. The extension of the infested country since it shrank to insignificant proportions in 1896-7 until the year 1913 has been described in a previous paper.\* During the past five years this progress has been continued and the new country involved is shown in Map 1. The present area of this belt is estimated at about 4,500 square miles.

The value of careful notes on the channels along which the fly has spread lies chiefly in the accumulation of information concerning factors which favour the pest. It is unfortunate that circumstances have not permitted of more detailed work in this connection, but such observations as have been made were carried out with this express object in view. The practical point lies in the possibility of rendering threatened areas unsuited to the pest or of interposing a barrier and thus checking the further extension of the belt.

Broadly speaking, the contentions of the early hunters concerning the association *G. morsitans* with big game are fully supported in this area, although this is not invariably the case elsewhere. The increase of the fly and the extension of its boundaries have corresponded with a notable increase of the larger antelopes, and to a less extent of buffalo. The new territory occupied by the fly is all game country. The most rapid extension has taken place through country where game abounds; fly is

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\*Bull. Ent. Res. v, Sept. 1914, pp. 97-110.

most abundant at points where game congregates during the latter part of the dry season, and the advance appears to have come to a standstill at more than one point where the country beyond is sparsely inhabited by game.

These statements call for some amplification. A glance at Map 1 shows that during the years immediately following the rinderpest epizootic in 1896, the fly was confined to the vicinity of Manzituba Vlei.\* From this vlei in a direction roughly S.S.W. lies a practically unbroken stretch to the Shangani River, in which game is now present in almost primitive abundance, and as the map indicates, a notable extension of the fly has taken place along this channel, and is still in progress. In a direction more S.W., however, the edge of the belt has been at a standstill in the neighbourhood of the old Native Commissioner's camp at Kariyangwe since 1907. West of this station the country is notable for its rocky character and the scarcity of antelope, and it appears probable that the area between this point and the Zambesi River never has been fly country.† At the point marked Manjolo on the Nogola River game, especially eland, is moderately abundant.

It is possible that the reason for the lack of fly in this region may be due to unsuitable vegetation or other causes; but there are numerous spots where the vegetation is to all appearances quite suitable, and there is on the other hand reason to believe that, where game is sufficiently abundant, tsetse can exist in great numbers although the vegetation does not seem to afford ideal conditions. The country lying immediately to the north of the headwaters of the Mzola River, for instance, is very open, being in fact known as the Matobolo Flats, the native name "Matobolo" signifying an open plain. Dotted about the plain are a number of small termite mounds, which bear stunted trees of an evergreen habit. In crossing a portion of these flats in 1916 the writer was surprised to find *G. morsitans* abundant, sheltering in the shade of the stunted trees and darting out to attack the passer-by. Game is plentiful, and certainly constitutes the only apparent source of blood to the flies, which in hot weather appear to be extremely confined in their range. It would appear therefore that a very limited extent of shade will serve *G. morsitans*, provided that living blood is sufficiently plentiful in the immediate vicinity. Where the food supply is more uncertain, greater freedom of movement is doubtless a necessity. We cannot therefore attribute the unsuitability to tsetse of certain tracts of country exclusively to small differences in the type of vegetation, which are not apparent to the eye. We must look for some combination of factors in which facilities for more or less regular meals are probably very important.

The extension of the Sebungwe belt to the S.E. and E. calls for little comment, as the country involved is all well stocked with game.

The writer is not familiar with most of the country to the north of the belt. Fly was located on the lower Sengwe River in 1913, and this belt was supposed to be isolated. It is possible, however, that it may in reality have been connected with the main belt in the vicinity of Sinatchungwe's kraal. In any case, reports of

\* On the authority of the late Mr. Val Gielgud, formerly Native Commissioner for this district.

† In 1868 James Chapman remarked on the absence of fly on the south bank of the Zambesi between the Gwaai confluence and a point a few miles below the Sebungwe River confluence, a distance of about 30 miles. This strip contains no game except a small variety of duiker.—"Monograph of the Tsetse Flies," E. A. Austen, p. 143.

Government officials and hunters indicate that this is the position at the present day ; but whereas the region of the Sengwe is heavily infested, the narrow neck joining the two belts contains but little fly, and mules, at least, still pass through with apparent impunity. A considerable extension of the belt in the region of the lower Sengwe and on the Zambesi is also reported.

(2) *Umniati Belt.* The history of this area is of peculiar interest. In 1896-7 it appears to have shrunk to very small dimensions, but the exact position at that time is somewhat obscure. Subsequently the belt extended, in common with other fly areas in the territory and, it may be added, in the presence of considerable quantities of big game. Its present area is judged to be about 1,000 square miles. The writer first visited this part of the country in November 1910, when the southern limit of fly on the Umniati was about seven miles further north than it is to-day. At that time game was plentiful on both sides of the river but especially on the west, and included elephant, rhinoceros, eland, kudu, sable, waterbuck, impala and wart-hog, whilst bushbuck was, and remains still, moderately abundant along the river itself. In addition to game, large and numerous troops of baboons frequented the river, and have not decreased in any way to the present day. These animals are, as a matter of fact, more abundant in this region than in any other part of the territory with which the writer is familiar. The adjacent portion of the Hartley district has been open to free shooting, with one break, since 1905, and this has had an adverse effect on the game on the Sebungwe side of the Umniati river. Professional hunters, camping in the "open area," have poached regularly beyond the Umniati and of late years game has become very scarce where it was abundant as late as 1910 and fairly abundant up to 1912. Between 1910 and 1912 the fly extended about seven miles up the Umniati, but since that year it seems to have come to a standstill at this point. The belt now extends westward as far as the base of the Mafungabusi plateau. The writer has never visited the extreme northern limit of this belt, but is quite familiar with that portion which lies south of the latitude of the Umniati-Sakugwe confluence. In this part it may be stated that fly is everywhere scarce away from the vicinity of the Umniati River, but at one point on the western side four or five miles above the junction with the Njongwe (Dumbwi) it is present in great numbers. According to native evidence this is the spot where the fly survived the adverse conditions of 1896-7, and it is certainly the locality where the marked reduction of the game at the present time has had no appreciable effect in reducing the numbers of the pest. The persistent presence of large numbers of baboons is, however, a complicating factor, and the association of the fly with the vicinity of the river is consistent with the theory that these animals may be acting as hosts to the insect. It is not necessary to enter at present into the conflicting evidence as to whether these animals ever allow themselves to be fed upon by tsetse. It is desired merely to record the facts regarding the Umniati fly belt as far as they are known at present. It may be added that baboons do not enter as a serious factor throughout the great bulk of the fly-infested country in the territory.

It is to be noted that the fly has shown no tendency to spread from this belt in a south-easterly direction towards the railway line, although the country is apparently suitable. The game has been kept down very effectively by hunters in this area for a number of years past.



(3) *Northern Belt.* The writer has not visited this area since 1912 and is unacquainted with the conditions prevailing there at present. The region is untouched by civilisation, and since the year of the rinderpest epizootic the fly has, according to numerous reliable reports, increased and spread very greatly. The latest reports from the Native Commissioners indicate the present extent of tsetse as shown in the map. The infested country is estimated to include about 2,500-3,000 square miles at the present day.

(4) *Jetjenini Belt.* The infested country in this region remains untouched by civilisation as far as the forest is concerned, but owing to its accessibility it is a favourite shooting area amongst hunters, and game is less plentiful than it has been in the past. Tsetse occurs, but not in great numbers, and of late years has shown little or no tendency to spread. In 1914 an outbreak of trypanosomiasis amongst some cattle which had been running for eight or nine months on the Chumsenga River, which was supposed to be outside the fly belt, gave the impression that a southward movement was in progress. This may indeed have been the case at the time, although the evidence that this river had only recently become infested was inconclusive, and fly was certainly present when the cattle were taken there, as proved by the report of a trooper of the B.S.A. Police the previous year. It may be mentioned that game, especially kudu, sable and wart-hog, was found to be moderately abundant in the neighbourhood in September 1914. It is also significant that the northern limit of native-owned cattle in this region has apparently remained the same for a number of years past, namely, about the headwaters of the Ridziwe River and along the Mvume. Capt. Thornton, of the B.S.A. Police, found tsetse at Doma Hill in 1909 and this still marks the southern limit of fly in this direction. The stationary nature of the belt is all the more significant in the light of the fact that in pre-rinderpest days the fly used to extend considerably further south. The southern limit of fly in this district in 1896 according to Mr. R. T. Coryndon, C.M.G., now Governor of Uganda, is marked on the map. It may be added that there is a fairly wide extent of primitive country between the present limits of the fly and the limits given by Coryndon, although a portion of the intervening area has been settled. The unsettled area doubtless contains a moderate amount of game at certain seasons, though the writer has seen very little in the course of some three journeys; but the region is too near to settlement for large game to be really plentiful. The Jetjenini fly belt is about 450 square miles in extent.

(5) *Suri-suri Belt.* From all appearances tsetse has now died out in this area. The history of the fly in this belt up to the year 1913 has already been published, but in order to make the sequence of events clear it is necessary to recapitulate. Tsetse in the Hartley district shared in the great shrinkage of 1896-7 and indeed has not reappeared in many parts which were formerly infested, notably in that portion lying east of the railway. The late Mr. Scott, of the Native Department, formerly resident in the Hartley district, supplied information to the Director of Land Settlement, dated 12th June 1909, of which the following is a condensed version. "In 1895 there used to be a fly belt between a point four miles from Old Hartley and the headwaters of the Ngombe or Mombe river. In September 1897 I never saw or heard of fly during a trip from Fort Martin, to the Beatrice Mine, to the Mgezi at the Manizi range, down between that river and the Msweswi to the Singondo junction

with the Umniati, and then to Hartley. Natives stated that fly had disappeared on game being destroyed by rinderpest. Subsequently to that year I criss-crossed the whole district, except the piece of country bounded on the east by the railway, north by the Hastings road and south by the Msweswe, and never found fly at any time. In 1898-9 I heard of it at the water-holes and headwaters of the Shagari river. In 1901 I heard of its being in the country between the Beri and Umfuli rivers, near their junction, but messengers sent out did not bring any in nor did they find any. In the latter part of that year or early in 1902 I caught tsetse on the railway line on the headwaters of the Suri-suri River. In August 1902, J. McAdams brought in a number that he had caught (some six or eight miles, I think) west of the Golden Valley Road on the Suri-suri River." (Note.—The last statement should probably read "west of the Suri-suri River on the Golden Valley Road," as the latter runs approximately east and west.)

It is evident therefore that from 1898 onwards tsetse began to make its presence felt again in the Hartley district, and that by 1902 it was present in considerable numbers in the neighbourhood of the Suri-suri and Shagari Rivers. There is ample evidence to the effect that during the years following the fly was abundant in certain parts of this area and continued so until the year 1908.

The course of events in the Hartley district constitutes such a valuable record in connection with the question of the relation of tsetse-fly to the larger mammals that at the risk of being accused of labouring the various points the writer is impelled to place as much of the available evidence as possible on record. From a strictly scientific point of view it is rather unfortunate that the old fly area in this locality has been deforested, as there is a tendency at present to ignore the events, obvious at the time, which preceded the deforestation. The points it is desired firmly to establish are (1) that there was a notable reduction of fly in the basin of the Suri-suri, Umsweze and Shagari Rivers between the years 1908 and 1913; (2) that there was a coincident reduction of large game; (3) that a considerable area surrounding the upper portions of the three rivers mentioned still remained virgin forest as late as 1913, when the wood contractors commenced to work this area in connection with the supply of timber and firewood to the Cam and Motor mine.

The year 1908 seems to have been marked by an unusually large number of cases of trypanosomiasis around the Suri-suri fly area, and the losses continued during the early part of 1909. This may have been due to a culmination in the numbers of tsetse, to the increased hunger of the flies due to the reduction of game up to that year, or to increased agricultural and industrial activity in the neighbourhood. A number of farms on the railway line near the headwaters of the Suri-suri were taken up in that year, and considerable losses were experienced in this region. In addition the Veterinary Department records losses at the Dreadnought and neighbouring mines north of Gatooma, at Hippovale farm on the Umfuli River, on the Eiffel Flats east of Gatooma, and numerous cases amongst transport oxen working from Gatooma and Hartley.

Direct evidence as to the abundance of the flies themselves is also not lacking. Mr. W. E. Masters, of the Dreadnought Mine, in a letter to the writer states that in a well-known vlei slightly to the east of the Dreadnought Mine on the Hartley-Golden Valley road, fly about this time was present in hundreds on every warm day. Mr.

Ll. E. W. Bevan, Veterinary Bacteriologist, records that in this year a local resident caught fly for him "by the matchboxful" at the foot of a range of hills running N.E. from Gatooma, parallel to and not far from the railway line. Dr. Alex. Mackenzie's experience on the Mowiri River in this year and other evidence in regard to the abundance of fly near the Suri-suri have already been recorded. There appears therefore no room for doubt that tsetse was really abundant in certain portions of this area in 1908.

When the writer commenced investigations in this region in the latter part of 1909 he naturally sought to profit by the experience of local residents in regard to the spots where fly was to be found in most abundance. Early in August Dr. Mackenzie very kindly accompanied him to the Mowiri River, where fly had caused him so much inconvenience the previous year, and the writer revisited the area almost monthly in the latter part of 1909 and in 1910. The highest number of flies seen in any one day was nine, notwithstanding the fact that the whole object of the visit was to search for them. On several days none at all were encountered. Early in 1910 a visit was made to the vlei near the Dreadnought Mine and no tsetse were seen in the course of two days. The range of hills near Gatooma was also visited about the same time, with completely negative results so far as finding tsetse was concerned, and as a matter of fact farms along the north-west side of the railway line, including the hills mentioned, began to be taken up from 1909, and cattle were introduced, as they would not have been had the fly been much in evidence at that time. Some of these cattle contracted trypanosomiasis, but the losses were not sufficient to cause the abandonment of the farms, and cattle have been present continuously ever since. It should, however, be mentioned that Mr. Ll. E. W. Bevan, employed an injection as a cure for trypanosomiasis in cattle with considerable success at this time.

Reference to the annual reports of the Chief Veterinary Surgeon for the years 1909 to 1912 is very instructive, although the record is to some extent complicated by the fact that Gatooma is the base for certain mines in or near the Umniati fly belt and for hunters taking advantage of the free shooting, who have been in the habit of camping annually on the Umniati river, frequently in the fly. However, references to trypanosomiasis in the Hartley district for the four years mentioned are as follows:—1909: "In Hartley district the mortality during the year was very considerable. Accurate figures are not available, as many animals showing symptoms of illness were at once disposed of." Incidentally, the increased mortality was attributed to the increased number of cattle employed for the mines and on farms in the district. 1910: "The mortality from this disease has, *especially in the Hartley district*,\* shown a marked decrease. Whether such decrease is due to the effects of the suspension of the game laws or not, I am not prepared to discuss here, but an effort will be made to obtain further information from members of the staff and residents in the affected districts." 1911: "Only a few cases of this disease occurred, in the districts of Hartley, Lomagundi and Mafungabusi, which contain various areas in which tsetse-fly exists." 1912: "In Hartley district fly are still to be found in small numbers in the farming and mining areas, but only a few deaths of cattle were reported."

Although, owing to special circumstances, which will be dealt with shortly, the month of December 1913 marked the commencement of a sharp increase in the

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\*Author's italics.



number of cases in the Hartley district, the impression up to that time is summed up in the following passage from the report of the Director of Agriculture for that year :—

“The free shooting of game allowed in the neighbourhood of Hartley, with the object of eliminating tsetse-fly from that populous area, appears to have achieved its object in a very large measure, as the fly is by no means as abundant as formerly ; and though domestic stock are more widely distributed, very little is heard of their being fly struck. The suppression of trypanosomiasis amongst cattle, consequent on the reduction of fly by driving away the game, cannot be proved to demonstration, but certainly, as in the destruction of dogs to eliminate rabies, everything points to this result having been obtained.”

It will be seen therefore that not only the writer's personal observations but the whole veterinary record for the district prove the great reduction of fly that took place in the area between the years 1908 and 1913.

The fact of a great reduction of game having taken place during the same period scarcely needs proof, seeing that free shooting was allowed in a comparatively populous district. The writer noted a steady diminution in both game actually seen and fresh spoor from August 1909 onwards, and the increasing difficulty of obtaining a “bag” was a common complaint as time went on, the scarcity of wart-hog, which was at one time abundant, being especially noted. The marvel is that any game survived the constant persecution ; but so attractive was the area at certain seasons of the year that big buck were to be met with at times even after the deforestation commenced and are probably not altogether absent at the present day. Professional hunters shot largely in this area up to about 1909, as the remains of their camps, littered with bones and refuse, in that year indicated. They apparently did not find it worth while in the years following, but residents, at Hartley especially, made hunting excursions to the Suri-suri an agreeable week-end recreation as long as there was a reasonable chance of getting a shot. The reduction of game is actually a more difficult matter to prove, apart from personal observations, than the reduction of fly, but the Hartley residents who were in the habit of using this area as a happy hunting ground are not likely to call the statement into question.

The fact that a large area remained untouched by civilisation, with the exception of the reduction of game, at the time cutting on the wood contract commenced, is easily established. The writer has in his possession a copy of a large scale map drawn up by the contractors showing the area blocked out for wood cutting, the areas reserved for other mines and the remaining untouched forest in the neighbourhood. There was a continuous area of virgin forest not far short of a hundred and fifty square miles, embracing the bulk of the old fly belt, at the time the wood cutting concession was granted, dating from the 1st January 1913 (see Map III).

As it is impossible that the presence of European settlement could have any direct effect on tsetse-fly four or five miles away in the shady depths of its native forest, there are only two alternative explanations of the Hartley phenomenon. Either the reduction of the game was the direct cause of the reduction of fly or we must appeal again to natural causes and coincidence.

In connection with the Cam and Motor wood contract, a light railway was run down into the fly area in 1913 and in October of that year a considerable number



of working oxen were introduced. A number of these oxen contracted trypanosomiasis. The Veterinary Bacteriologist in his report for 1914 states:—"It is estimated that nearly 25 per cent of these transport animals became infected, but it is impossible to state definitely how many were suffering from trypanosomiasis alone, and how many were the victims of starvation during the drought of the past season."

In view of the heavy losses from trypanosomiasis that have occurred of recent years amongst cattle living outside the known fly areas, these figures are far from suggesting any great abundance of testse in the Suri-suri at the period involved.

The apparent effect of the clearing of the forest, possibly combined with the introduction of an abundant food supply in the shape of oxen amongst the lingering tsetse, was interesting. The forest was cut from the main railway line back towards the Mowiri River, skirting the edges of the alienated farms adjoining the railway, and what little fly remained would presumably follow the receding forests. Away from the edges of vleis and water-courses, however, the forest becomes leafless after the end of July and is not frequented by tsetse at this time, hence the fly may be judged to have moved back along the Mowiri to the Hartley-Shagari road. This road runs through the farm Ameva close to Hartley and on this farm for the first time there was an outbreak of trypanosomiasis in 1914. At the same time two cattle on Hippovale were suspected of being struck, but blood-smears did not confirm this. The traffic between Shagari and Hartley would account for the fly being carried in the direction of the latter, and it may be judged that the first effect of the clearing of the forest was to scatter the remnants of the fly. A few fly were still to be found in 1914 to the S.W. of the cleared area, associated with the Nswunzwe river, but in June of that year the writer encountered only a single specimen, when looking for fly in this locality. The scattered remnants of the fly apparently died out in a comparatively short time, and no cases of trypanosomiasis associated with the Suri-suri area have been recorded during the past two years or more.

(6) *Melsetter Border Belt.* Since 1914 cattle on certain farms close to the Portuguese border in the Melsetter district have become infected with trypanosomiasis during the summer months. This has been due to the extension of a belt of fly in Portuguese Territory towards and up to the Rhodesian border. In this case it is not *G. morsitans* that is implicated, but *Glossina brevipalpis*, Newst., and *G. pallidipes*, Austen. These two species are intermingled in the strip of country lying across the border from the affected farms. In this region the border practically follows the division between the high and low veld, although Spungabera, the seat of government for the Mossurize district of the Moçambique territory, is situated on the high veld. Most of the farms on the Rhodesian side are of an open character and certainly not suited to become permanent fly haunts. The low veld on the Portuguese side of the border is heavily afforested, and the forest extends into Rhodesian territory up the river valleys, several of which are very deep, the water-level being sometimes 2,500 feet below the surrounding country. In other places the forest extends up the side of the escarpment across the border; whilst one or two farms bear open forest, distinct from the sub-tropical growth found in the river valleys. Experience indicates that cattle on the Rhodesian side are only subject to infection during the wet season, and it is judged that the flies extend their range at this season, as is the case with *G. morsitans*. Practically all cases are traceable to stock having been in contact

with the forest during the wet season. They appear to graze on its outskirts with impunity in the winter. No specimens of tsetse have as yet been taken within the Rhodesian border in this region, and the flies in 1917 were present only in small numbers in the neighbourhood of the border on the Moçambique side. On the other hand the losses in cattle have been severe in some cases, as many as eighty-six head during the past season. There is thus reason to think that in Melsetter, as elsewhere, some agency other than tsetse may serve to transmit the infection from an infected beast to others herded in its vicinity.

The situation in the Melsetter district is probably unique in its way, constituting an instance where a very considerable degree of settlement and development lies immediately adjacent to practically primitive conditions across a boundary which is both political and natural.

### Breeding Haunts of *Glossina morsitans*.

Very little work has been carried out in this connection, the only area searched for pupae since the writer's previous work on this subject being Sipani Vlei, lying east of the Sengwe River and north-west of Gokwe in the Sebungwe district. This Vlei is intensely infested with fly late in the dry season and bears clumps of evergreen trees on termite mounds, as in the case of Manzituba Vlei, which has already been described.\* In one hollow tree alone some forty live pupae were secured and several hundreds of empty pupa-cases, constituting probably a record for any single location. Pupae could be found by searching in almost any sheltered situation at the bases of the evergreen trees near the Vlei and a considerable number were there secured. It may be stated, as bearing on the question of the season during which *G. morsitans* breeds most freely, that the large haul mentioned above was secured in November 1914, and that at the base of the same tree in August 1916 less than ten live pupae were secured, although fly was noted as being "extremely numerous and attentive." This observation is of little importance in itself, but is mentioned here as it happens to be in accordance with the conclusions of Lloyd from careful notes made in Northern Rhodesia.† It is to be remarked also that in the writer's previous work in this connection, in August 1911, only four live pupae were secured amongst a total of ninety-one, the remaining cases being empty. Lamborn also supports Lloyd's observations in this particular,‡ and it would seem that the diminution in the breeding rate and the prolongation of the pupal period during the colder months of the year is more or less established. Lloyd, however, came to a further conclusion, namely that breeding practically ceases during the wet season§ and that the latter part of the dry season, from July to October or November, would therefore comprise practically the whole of the active period of reproduction. This is exactly the season when *G. morsitans* in Southern Rhodesia is concentrated in the permanent shade bordering on vleis, rivers, etc., and it would certainly be of considerable interest if Lloyd's deductions in this respect were correct. The statement, however, needs confirmation, and whilst the writer is unfamiliar with conditions north of the Zambesi, it would appear that the deduction is based upon

\* Bull. Ent. Res., ii., p. 357.

† Bull. Ent. Res. v., p. 58.

‡ Bull. Ent. Res., vii., pp. 29-50.

§ Bull. Ent. Res., v., p. 58.

a questionable premise, namely, that the distribution of the fly is the same in both wet and dry seasons. If this is the case in the locality where the observations were made, the results obtained have great value; but it is certainly not the case in Southern Rhodesia, nor, according to Lamborn, in Nyasaland. The vast bulk of the forest in this territory consists of some three species of *Brachystegia*, producing the type of forest known to the Matabele as "gusu," and the well-known mopani. The habit of "gusu" forest varies with the soil and subterranean water-supply. Broadly speaking, the trees concerned appear to become leafless all over the territory at about the same time of year, namely late in July. In many places, as at Salisbury, the new leaves appear again almost immediately, and if this were the case everywhere, it is to be presumed that no marked seasonal change in the distribution of fly in gusu country would take place. In all the fly country known to the writer, however, the forest does not as a rule come into leaf again until the middle of November or later, being apparently dependent to some extent on the commencement of the heavy rains.\* As a striking instance of the effect of different soil conditions, in August 1916, the writer crossed the Mafungabusi plateau towards the Umniati River. Water is well held on the plateau, and permanent streams pour down the gorges into which the edge is broken, only to lose themselves during the dry season in the deep sand which extends from 15 to 20 miles between the plateau and the Umniati River. On the plateau the whole forest was in full leaf, whilst between the plateau and the river it was quite leafless. With respect to mopani, this type of forest has never been noticed in foliage between the end of July and the beginning of November and has frequently been noted as leafless after the middle of the latter month.

During the leafless period tsetse congregates in those parts of the fly belt where there are evergreen trees, such as *Ficus*, *Acacia*, *Parinarium mobola*, *Diospyros mashuna*, *Kigilia pinnata*, etc. Such trees occur on the banks of water-courses and the edges of vleis, even though these dry up on the surface during the dry season. Some of them are also found on "ant-heaps" thinly scattered through the forest. In some spots, as on the edges of vleis, where there is abundant underground water the *Brachystegias* come into leaf again in August, even though the vast majority of the same species in the vicinity remain leafless till the advent of the rains.

The concentration of *G. morsitans* from August to November and its general distribution during the wet season and first half of the winter renders observations bearing on the question of its most prolific breeding season very difficult indeed. There is a general opinion that the fly is most abundant in October and November, and this may be the case. It is certainly most in evidence during these two months, but, being much more widely scattered at most other times, it is difficult to draw comparisons. Nevertheless, the establishment of the fact that the hot months preceding the rains are of maximum importance to the welfare of the fly would be of considerable value. It may well be that, apart from the breeding rate, the summer months show the greatest mortality amongst the flies from the attacks of insect enemies and that they generally become reduced in numbers during this period; but as the earliest month with which we can compare the prevalence of fly at any

\*An exception occurred during the present year (1918), apparently due to the phenomenally heavy rains of last season, the gusu forest being generally two months ahead of its usual time. The mopani, however, was not affected.



particular spot with its prevalence in November is August, between which month and the past wet season the cold months of May, June and July have intervened, we are in a similar position with regard to judging whether the fly loses ground in the wet season or not, as in estimating the comparative breeding rates. Although the connection may not be apparent, such facts might well shed some light on the question of the dependence of *G. morsitans* on the larger fauna of the forest. The matter will be referred to again under its own heading.

#### **Transmission of *T. pecorum* in the Absence of Tsetse.**

In spite of the fact that direct experimental proof is still apparently lacking, evidence indicating that *Trypanosoma pecorum* is commonly spread amongst associated animals in the absence of *Glossina* has accumulated in different parts of Africa during recent years to such an extent that the fact appears now to be widely accepted. (Bull. Ent. Res., viii, pp. 35-41.) In any division of the continent where fly belts occur this danger must necessarily be of considerable importance, and not least in Southern Rhodesia with its comparatively large European population. Not only is there conclusive evidence with regard to this form of transmission in the territory, but fresh instances demonstrating its practical importance occur almost every season. If all cattle owners within measurable distance of the fly areas were aware of the danger of allowing cattle which have been exposed to fly to mingle with healthy cattle, it is apparent that the losses from trypanosomiasis in the territory would be materially reduced. Unfortunately, transport riders and others who are most likely to penetrate fly country with their waggons are not easily reached through the usual mediums of publication.

It may be pointed out that considerable confusion concerning the occurrence of tsetse in various parts, particularly in the Hartley district, has been occasioned by the spread of "fly disease" amongst animals which have never been in a known fly belt, and that in drawing conclusions as to the former extent and abundance of tsetse in this district the possible rôle of other vectors must not be ignored.

#### **Relation between *G. morsitans* and Big Game.**

Whilst it is obvious that there are still considerable grounds for a contrary opinion, accumulated evidence in Southern Rhodesia constitutes a case for a vital association between *G. morsitans* and the larger fauna of the forest, which it is impossible to ignore. As already stated, it is possible that baboons play a more important part in some areas than was previously recognised.

The weakness of the contrary theory appears to the writer to lie in the fact that no alternative explanation has been forthcoming of the extremely striking phenomena that support the assumption of a vital association between the two forms of life, at least in South Africa. It is not the writer's intention to detail the arguments in favour of the theory, as these have already been dealt with in a previous paper, but it may be as well to consider such facts as have been made public which weigh on the other side. That there are difficulties in accommodating all the known facts is freely admitted, but these, surely, sink into insignificance in comparison with the difficulties of explaining a vast amount of evidence on any other basis. It is possibly true that *G. morsitans* is not everywhere dependent upon big game, in the restricted sense, but that the fly is and has been dependent upon the larger mammals throughout the greater portion of its range in South Africa is more than probable.



The main arguments to the contrary are apparently as follows :—

(1) The occurrence of fly in numbers in certain tracts where large game is apparently absent.

(2) The fact that a small proportion of the game survived the rinderpest in 1896, so that the fly could not have been absolutely starved.

(3) The discovery of nucleated corpuscles in the stomachs of captured flies, indicating an avian or reptilian diet.

(4) The fact that fluctuations in the distribution of *morsitans* have been noted apart from any wholesale destruction of game.

(1) Observations of this nature on excellent authority have been published relative to Northern Rhodesia, Nyasaland, East Africa and elsewhere, and it would be idle to dispute that such observations carry very considerable weight. On the other hand, in regard to Northern Rhodesia Lloyd, whilst noting that game was not always abundant where tsetse were very much in evidence, nevertheless found excellent cause to conclude that large game is at least highly important to the welfare of the fly.\* Again in Nyasaland, whereas certain casual observers have disassociated fly and game, Lamborn, specially engaged in tsetse-fly investigations, came to the opposite conclusion. The well-known statement of Sir F. J. Jackson relative to a dry stretch of country lying between the Msologeni and Tsavo Rivers in British East Africa in 1892 was apparently due to a single and presumably rapid journey in the driest part of the season. It appears that the investigators who are most inclined to associate *morsitans* and the larger mammals are those who have continued their investigations over a considerable period in one territory, and have also paid special attention to the bionomics of the fly. The bulk of the evidence to the contrary has not emanated from entomologists, but from the comparatively superficial and disconnected observations of men of other professions.

With reference to Lloyd's observations on the influence of the prevalence of game on the ratio of the sexes caught, the following may be of interest :

November 1910, Gorai River, Zambesi Valley, Lomagundi district. Game, except warthog and duiker, practically wanting ; 37 males and 45 female flies caught.

December 1910, Umniati River. Game and baboons plentiful ; 57 males and 20 females caught.

April 1911, Gorai River, Zambesi Valley, Lomagundi. Game moderately plentiful ; 53 males and 3 females.

August 1911, Manzituba, Sebungwe district. Game abundant ; 143 males and 74 females.

October 1911, Umniati River. Game present but not very abundant, baboons abundant ; 85 males and 50 females.

June 1914, Thirty-one flies sent in by hunter, probably taken on Umniati River where game was by this time scarce, although baboons abounded ; 25 males and 6 females.

November 1914, Umniati River. Game scarce but baboons abundant ; 100 males and 28 females.

August 1916, Sipani Vlei, Sebungwe district. Game abundant ; 32 males and 14 females.

\* Bull. Ent. Res. v, p. 60. and vii, p. 67-71.

These figures are more or less in accordance with Lloyd's results, and they also suggest that baboons may constitute an efficient substitute for game as a food-supply for tsetse. It should be noted that all the collections, except that near the Gorai river in April 1911, were made during the season when the fly is concentrated, and that the collection referred to is the only one showing extreme disparity in the proportion of the sexes. During the period of concentration there is no scope for the females to separate from the males, whilst during the remainder of the year they have a considerable extent of forest at their disposal. This fact may have some bearing on the result.

(2) The fact that a material percentage of the game survived the rinderpest is an obstacle in the way of accepting the theory that the reduction of the game at this period was the sole cause of the immense reduction of the fly. We are, however, in the same difficulty with regard to the disappearance of fly from many belts in South Africa, following the wholesale destruction of game by hunters, for in neither case was the removal of the animals complete. It is in this connection that further evidence as to the question whether the hot months preceding the rains are of maximum importance to the fly or not is required. Supposing this to be the case, the change in the habits of game consequent on persecution might have a very considerable effect. The most favoured haunts of the fly during the season of concentration are the edges of vleis, and under natural conditions this places them in a position to secure more or less regular meals; for, as is known to all hunters in Africa, the game comes regularly to graze on the green grass in these vleis in the afternoon during the hot dry months and must necessarily pass through the haunts of the fly. Under persecution game develops a habit of visiting the vleis at night and leaving at dawn, so that the fly does not get the same opportunities for feeding. It is conceivable that the great losses amongst the game during the rinderpest may have produced a similar shyness, which, supplementing the undeniably immense reduction in numbers of the animals, might account for a practical cessation of breeding, during what may be the most important period. During the wet season the presence of only a fraction of the usual food-supply scattered throughout the forest would in any case have a very deleterious effect.

Some of the more vigorous opponents of the game and fly theory appear to think it necessary to suppose that every fly was starved at the time of the rinderpest if the lack of food is to account for the fly's disappearance, but this is obviously quite unnecessary. A practical cessation of breeding would produce the same result and this might conceivably be brought about by a greatly reduced and uncertain food-supply. We know little enough concerning the factors that induce the fly to breed, but we do know that regular meals are necessary to the insect in confinement, and it seems almost probable that a state of semi-starvation in nature would either cause the insects to cease breeding, or that pregnant females, with growing larvae draining their vitality, would tend to die off or abort in such circumstances. Unfortunately it is impossible to verify such facts under artificial conditions.

The most striking point in connection with the controversy is, however, that not a single alternative suggestion of any weight has been made. It has been vaguely suggested that climatic conditions may have been accountable or that the fact of

feeding on animals suffering from rinderpest may have actually killed the flies. With respect to the latter, observations might have been made in East Africa during recent years, but it is on the face of it an almost incredible hypothesis. Moreover, if every fly was killed in this way does it not imply a very close association between animals subject to rinderpest and tsetse-fly? With respect to the climate the writer has been at some pains to obtain particulars of rainfall and temperature in Southern Rhodesia at the period involved and there is nothing whatever to suggest any remarkable deviation from the normal. The following returns were furnished through the courtesy of the Rev. E. Goetz, S.J., M.A., F.R.A.S., of Bulawayo.

A set of observations is on record from the Zambesi from 1891 to 1897, but some of these were taken at Baroma and some at Zumbo, a complete set for either station being lacking. These two stations are, however, only about fifty miles apart and the climates are more or less similar. It may be mentioned that fly apparently disappeared from this vicinity in the 1896-7 season and has not since reappeared. The records for three seasons ending 1896-7 are given on the opposite page.

If climatic conditions are to account for the widespread dying out of tsetse-fly at this period, one would expect either an intense general drought, an excessively prolonged period of dull weather and rain, an excessively high maximum or an excessively low minimum temperature, but there is no record of any such occurrence. As a matter of fact the seasons of 1889-90 and 1890-1 showed far heavier rainfall, as also did last season, 1917-18. Dull weather was so prolonged last season that the maize crop was largely a failure and no effect is apparent on the tsetse-fly. Seasons of much lower rainfall than 1896-7 had also no effect on the pest, and, as may be seen from the record, the maximum and minimum temperatures recorded did not actually vary as widely as those of the preceding years.

These figures would seem to dispose effectively of the theory concerning exceptional meteorological conditions, and at present we are altogether without any plausible explanation to account for the immense reduction of fly at that period except the slightly antecedent immense reduction of wild ungulates.

(3) The presence of nucleated corpuscles in the stomach of *G. morsitans* has been recorded by several investigators, but there is apparently only one record of any considerable percentage of flies showing this evidence of a non-mammalian diet,\* and the circumstances may have been exceptional. There is no doubt that a hungry *morsitans* is quite willing to feed upon any warm-blooded creature, and possibly any vertebrate, that comes within its notice, and in the case of certain large birds, the operation should not be difficult. Amongst those which no doubt contribute an occasional meal to the fly may be included the ostrich, cranes, herons, ground hornbills, vultures and various birds of prey, including eagles, owls, etc., and doubtless several other types. Such birds are obviously far too scarce or come far too rarely within range of the fly, to constitute an efficient substitute for the usual mammalian diet. That the vast majority of birds with their active dispositions and untiring pertinacity in pecking at insects serve to support *morsitans* is extremely unlikely, and there appears to be no evidence at all to suggest such a possibility.

\*[Lloyd, Bull. Ent. Res. iii, p. 236.—Of 52 flies containing blood, the nature of the blood cells could be recognised in only 20; of these, 5 contained non-mammalian nucleated cells.—ED.]

*Rainfall in inches at Salisbury, Mashonaland.*

Year.	July.	August.	Sept'm'r.	October.	Nov'mb'.	Dec'mb'r.	January.	February.	March.	April.	May.	June.	Total.
1895-96.	—	—	—	0.48	1.95	12.88	8.69	6.92	1.94	0.81	—	—	34.94
1896-97.	—	—	—	0.01	6.32	2.84	5.78	7.07	4.79	1.34	—	—	29.06
1897-98.	0.00	0.00	0.14	1.04	3.77	9.86	4.12	4.28	2.34	1.76	0.27	0.00	27.48
1898-99.	0.00	0.21	0.06	0.77	3.12	4.81	1.74	18.79	6.34	1.97	0.06	0.04	37.91

*Rainfall at Hopefountain, Matabeleland.*

Year.	July.	August.	Sept'm'r.	October.	Nov'mb'.	Dec'mb'r.	January.	February.	March.	April.	May.	June.	Total.
1894-95	0.00	0.20	0.00	0.92	1.64	2.86	5.63	9.25	4.01	0.23	0.00	0.00	24.74
1895-96.	0.00	0.00	0.00	0.20	4.74	10.61	3.46	3.63	(3.19)	(1.11)	0.00	0.00	(26.93)
1896-97.	0.00	0.00	(1.05)	(1.08)	1.85	4.72	8.74	4.38	5.52	0.00	0.00	0.63	27.97
1897-98.	0.00	0.00	0.00	0.00	4.99	7.82	7.75	0.98	4.69	0.47	6.31	0.04	27.05
1898-99.	0.00	0.00	0.69	0.41	3.29	5.05	4.44	7.07	1.79	2.48	0.41	0.04	25.67



*Season 1894-5, Baroma.*

	July.	August.	Sept.	October.	Nov.	Dec.	January.	Feb.	March.	April.	May.	June.
Mean Temp. (C.).	21.1	23.9	26.0	31.2	30.4	28.4	27.7	26.2	26.9	26.0		
Abs. Max. (C.).	28.7	32.2	33.0	41.2	39.0	35.2	35.3	33.1	32.4	32.3		
Abs. Min. (C.).	13.5	16.7	18.5	23.7	23.6	21.5	22.5	20.2	21.1	19.1		
Rel. Hum. (Mean).	61	58	50	41	52	62	68	84	75	65		
Rainfall (mm.).	10	2.0	13.0	0	68.9	49.6	86.9	27.10	20.9	16.2		

*Season 1895-6, Zumbo.*

	July.	August.	Sept.	October.	Nov.	Dec.	January.	Feb.	March.	April.	May.	June.
Mean Temp. (C.).	23.8	23.2	27.3	30.3	31.8	26.6	26.4	26.9	27.8	27.5	23.9	—
Abs. Max. (C.).	32.1	32.2	37.7	41.0	40.4	32.5	34.3	33.9	34.3	34.0	32.2	—
Abs. Min. (C.).	12.6	15.8	17.4	17.4	22.1	22.5	20.4	22.3	23.2	20.4	19.0	—
Rel. Hum. (Mean).	58	45	37	36	43	77	77	74	69	60	69	—
Rainfall (mm.).	0	0	0	0	50	33.04	62.22	21.70	49	0	0	—

*Season 1896-7, Baroma.*

	July.	August.	Sept.	October.	Nov.	Dec.	January.	Feb.	March.	April.	May.	June.
Mean Temp. (C.).	21.4	24.6	27.9	30.4	31.4	29.9	—	—	—	—	—	—
Abs. Max. (C.).	25.4	28.8	33.3	35.5	37.1	34.7	36.2	33.5	36.9	—	32.7	28.5
Abs. Min. (C.).	16.2	20.3	22.1	23.4	26.0	24.9	22.9	20.5	21.2	—	18.3	14.6
Rel. Hum. (Mean).	64	59	44	45	44	70	77	82	68	—	56	58
Rainfall (mm.).	0	0	8.4	24.2	8.4	14.58	12.55	89	0	—	0	2.6

With regard to the possibilities of an extensive reptilian diet, the larger reptiles are very scarce in most *morsitans* areas, and those that depend upon water are frequently altogether absent. A reptilian diet in many areas would necessarily be confined to small active lizards and chameleons. There is no evidence to suggest that the former would allow themselves to be fed upon to any extent, but chameleons are no doubt an occasional source of sustenance. Where the fly occurs along the banks of a fairly large river, however, there would appear to be no obvious reason why the same food-supply as that which serves *palpalis* should not suffice. *G. morsitans*, however, not only shows no predilection for such situations, but appears largely to avoid them. In the portion of the Umniati area already referred to, fly is certainly to be met with on the banks of the river itself, but is far more abundant in the adjacent forest. Its distribution therefore does not suggest a dependence on water-loving reptiles or amphibia. The pest actually lives in the old game haunts, now greatly depleted, but its habitat is constantly crossed by large troops of baboons moving to and from the river, and the paths of these animals are quite a conspicuous feature in this locality. Whatever diet is serving the fly along this stretch, however, it does not appear to produce the same increase in the pest as an abundance of game, as is shown by the lack of tendency to expansion since the reduction of the latter.

(4) The fact that fluctuations in the distribution of *morsitans* occurred previous to any wholesale reduction of game has really little bearing on the controversy, as nothing comparable with the phenomena which accompanied game reduction either locally or over a vast area is on record. It would be curious if tsetse-fly were not subject, at least in some degree, to similar influences to those which induce enormous fluctuations in the occurrence of many other insects, such as excessive multiplication of parasites and other enemies in a given area. *Glossina*, on account of its slow rate of reproduction, has less ability for recovery than the vast majority of other insects and so must be more liable to die out entirely under persecution.

To sum up, the case for the vital association of *G. morsitans* with the larger mammals appears to the writer to be extremely strong, in South Africa at least, and the evidence brought forward in opposition comparatively insignificant. There appears to be no direct evidence at all that *morsitans* feeds to any great extent on the smaller mammals under natural conditions, and the failure to find trypanosomes in the blood of such mammals by Montgomery and Kinghorn, and the Royal Commission in Nyasaland, constitutes distinct evidence to the contrary. Whatever may be the truth concerning the vital dependence of *morsitans* on the larger mammals in all areas, there is every reason to believe that the pest feeds upon them by preference and thrives best in their presence, and apart from any other consideration this constitutes a powerful argument for the suppression of the larger game animals, which are, in any case, bad neighbours to farmers and stockowners. The writer yields to none in his love of wild life, but when it comes to a choice between developing colonial territory economically or maintaining it as a zoological garden, there can only be one decision.

### Explanation of Fly-belts.

Austen on page 4 of his "Handbook of the Tsetse Flies" sums up the question of fly belts as follows:—"We are still somewhat in the dark as to

the factors that determine the limits of these 'belts,' but, although tsetse are undoubtedly dependent upon the blood of vertebrates for their continued existence, all recent evidence goes to show that the most important element is the physical character of the locality, and probably its suitability as a breeding ground." These remarks, of course, refer to tsetse-flies generally, and not *morsitans* in particular, but they leave out of consideration one rather obvious fact, namely, that the limits (of *morsitans* at least) are not necessarily permanent. Uninfested country adjacent to a fly area may be just as, or even more, favourable to the pest than the country it inhabits, the fact being demonstrated beyond question by its becoming heavily infested later. This has been occurring constantly in Southern Rhodesia since the rinderpest, the limit of the Sebungwe belt in certain parts, for instance, year by year traversing country obviously favourable on both sides of the line. The character of the locality, probably intimately combined with the incidence of a suitable food-supply, appears to account for the permanent limits of a belt; but what determines the transitory limits? Why is it that *morsitans* does not spread thinly over the whole of its potential area instead of inhabiting only a part? A fly belt has, in fact, a coherent quality of its own which needs explaining. Except during the season of concentration from July to November or later, the insect is as a rule by no means confined by physical conditions, as is shown by the fact that it more or less deserts its dry season haunts and spreads for some miles through the surrounding forest. As far as the writer has been able to ascertain its dispersing range does not exceed two or three miles, although there would seem to be no obvious reason why it should not be considerably greater. Again, the males are undoubtedly carried in all directions up to ten miles, or possibly more, by the movements of animals and human beings, but as Lamborn has shown in Nyasaland, they have both the instinct and the power to return to the point whence they were carried. The females seem only to seek animals and human beings for the purpose of feeding, and they are probably rarely carried any considerable distance. A strong "homing instinct" has been proved in respect of the males, and is to be inferred, at least over a comparatively short distance, in respect of the females.

The instinct of a fly to return to its haunts if it strays or is carried into unfavourable country, and the instinct of the males to return to the common haunt, where the females are to be found, are quite comprehensible; but they do not explain why favourable country adjacent to fly areas is frequently free of the pest. The fact of the matter seems to be that the fly is absolutely unadventurous, if the term be permissible, not ranging very far from its provedly favourable dry season haunts, nor allowing itself to be carried beyond the range of its power to return. It appears to the writer that this is to be explained, not by the lack of any tendency to wander, but by the possession of a *definite instinct to avoid wandering*; as it is to be supposed that in the absence of such a controlling instinct the flies under the stimulus of hunger would tend to range far and wide in search of food, as they well might do without encountering unfavourable conditions during nearly eight months of the year.

Assuming the existence of a strong instinct to avoid undue wandering, an explanation of its development on the basis of benefit to the species must surely be possible. One of the results is a more or less gregarious habit, but it is difficult to perceive what benefit the fly derives from this. Other things being favourable a single fly is

undoubtedly quite capable of looking after itself. The writer formerly inclined to the opinion that owing to the slow rate of breeding a gregarious habit, in enabling the sexes to meet and mate with the maximum certainty and regularity, might be of considerable value; but this theory would seem to be untenable in the light of the fact that there is no evidence to show that separate matings are necessary for each act of reproduction, the probability being that one act of copulation suffices for the female's life-time. The following suggestion is put forward for consideration, namely the value of *parental experience*. If there is one thing proved in connection with tsetse-fly it is its lack of adaptability. Under favourable conditions of forest and food-supply it frequently occurs in great numbers, but it is altogether absent from large tracts of country not affording its very particular requirements as to conditions, and tends to vanish entirely from its habitat if conditions be modified to its disadvantage. Given a wandering habit without a "homing instinct" a considerable proportion of the flies would tend to stray into unfavourable country and perish, and it appears conceivable that this fact may have led to the development of a strong instinct against wandering, *which functions whether the surrounding country be favourable or not*. In the vast majority of cases the fact of a fly being born at any particular spot proves the suitability of the locality to the species, and, as in the case of a certain conservative type of human being, what is good enough for the parents may be judged good enough for the off-spring.

### **The Manner in which Fly-Belts extend.**

This is a matter which has received some attention in this territory for a number of years past. The following rules are in accordance with the evidence accumulated, but must be regarded at present as merely tentative:—

(1) The advance does *not* take the form of disconnected offshoots at a distance from the main belt, but the whole movement is analogous to that of a rising flood, flowing along favourable channels and gradually extending the flooded area; (2) when the line of advance is interrupted in regard to permanent shade, as in crossing a watershed, the movement is confined to the wet season; (3) large numbers of flies are necessary at the previous dry season limit before a moderately wide region affording only summer shade can be crossed; (4) the fly can only spread in the presence of considerable quantities of the larger mammals.

The observations leading to these conclusions have been confined to Southern Rhodesia, but with the exception of the last they appear to be due to the same cause, which is independent of locality, namely, that the flies tend to remain in or return to one particular spot. The recently observed facts in this territory are altogether opposed to the theory that fly moves into and establishes itself in new districts with game, as has been stated by hunters and explorers in the past. Newly infested spots may be disconnected by a few miles from the former limits of the belt during the season of concentration, but the belt is continuous during the season of dispersion.

The fact of fly being only able to advance from one dry season haunt to another in the wet season is easily understood on the basis of the seasonal dispersion of the insect, which enables larvae to be deposited in the intervening forest until the neighbourhood of the next river, or other suitable dry season haunt is reached. When the next season of concentration arrives, the pest presumably concentrates in both



directions, a portion of the flies going back to the previous dry season haunt and a portion to the new, probably whichever is the nearer. The term "wet season" is not used loosely in this connection, notwithstanding the fact that the forest retains its foliage for some months after the cessation of the rains. The wet season lasts until April, and the three months following are, with the occasional exception of August, the coldest in the year, when the breeding rate appears to be at its lowest ebb and the tendency to extension is apparently checked by this fact. It is to be remarked that whereas advance along a well shaded river may be a more or less continuous or regular process, advance across interfluvial areas tends to be irregularly spasmodic. One dry season haunt having been attained, a pause of several years sometimes intervenes before the next step, and observations indicate that the next step, if it be a fairly long one, say five or six miles, is only possible when the fly has become really abundant at its previous halting place. As an instance, the passage from the Mzola to the Kana River in the Sebungwe district, a distance of about six miles, took place in the wet season of 1915-1916, but the fly was present on the Mzola in small numbers in 1912-13. Once the pest obtained a footing on the Kana, it increased rapidly in the presence of large quantities of game and late in 1916 had become fairly abundant, showing that it was no lack of favourable conditions ahead that caused the delay. The necessity for great numbers would appear to be explicable as follows:—At the beginning of the rains the flies scatter at once for a short distance in all directions from their narrow dry season haunts. A certain proportion of the females deposit larvae near the limit of their spreading range towards the new objective. Flies emerging from these also scatter in all directions, a proportion of the females again larvipositing in the required direction. The repetition of this process may result in the neighbourhood of the next river or vlei being reached before the next season of concentration; but it is clear that, the rate of reproduction being so low, only a small proportion of the numbers that originally scattered would extend so far in a few months, hence the necessity of large numbers to start with.

These remarks may seem somewhat academical, but they have a distinctly practical side. If the writer's deductions are correct, it would appear that the clearing of a comparatively narrow strip of forest might serve to check the advance of the fly, notwithstanding the fact that the males would constantly be carried across to the other side. The cost and maintenance of such a clearing would be prohibitive on a great scale, but by taking advantage of local conditions it might prove practicable to check the advance of a belt in some particular direction. An experiment of this nature was actually commenced at the south-western extremity of the Sebungwe belt in October 1918, but has had temporarily to be abandoned owing to the influenza epidemic.



Fig. 1. Gusu forest in full leaf near Gwaai River,  
Southern Rhodesia, October 1918.



Fig. 2. Leafless Gusu forest near Sipane Vlei,  
Southern Rhodesia, August 1916.







Fig 1. Mopani forest in full leaf in the Zambesi Valley, April 1914.

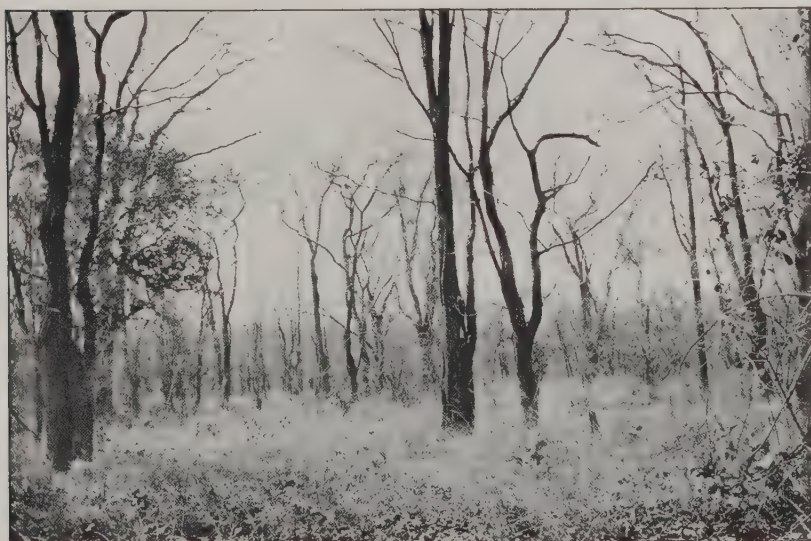


Fig. 2. Mopani forest in leafless condition, Wankie's District,  
near Gwaai River, October 1918.





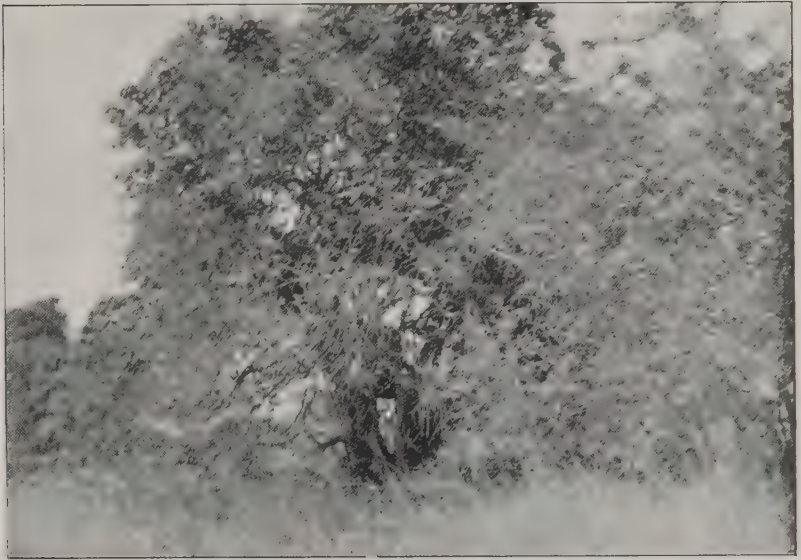
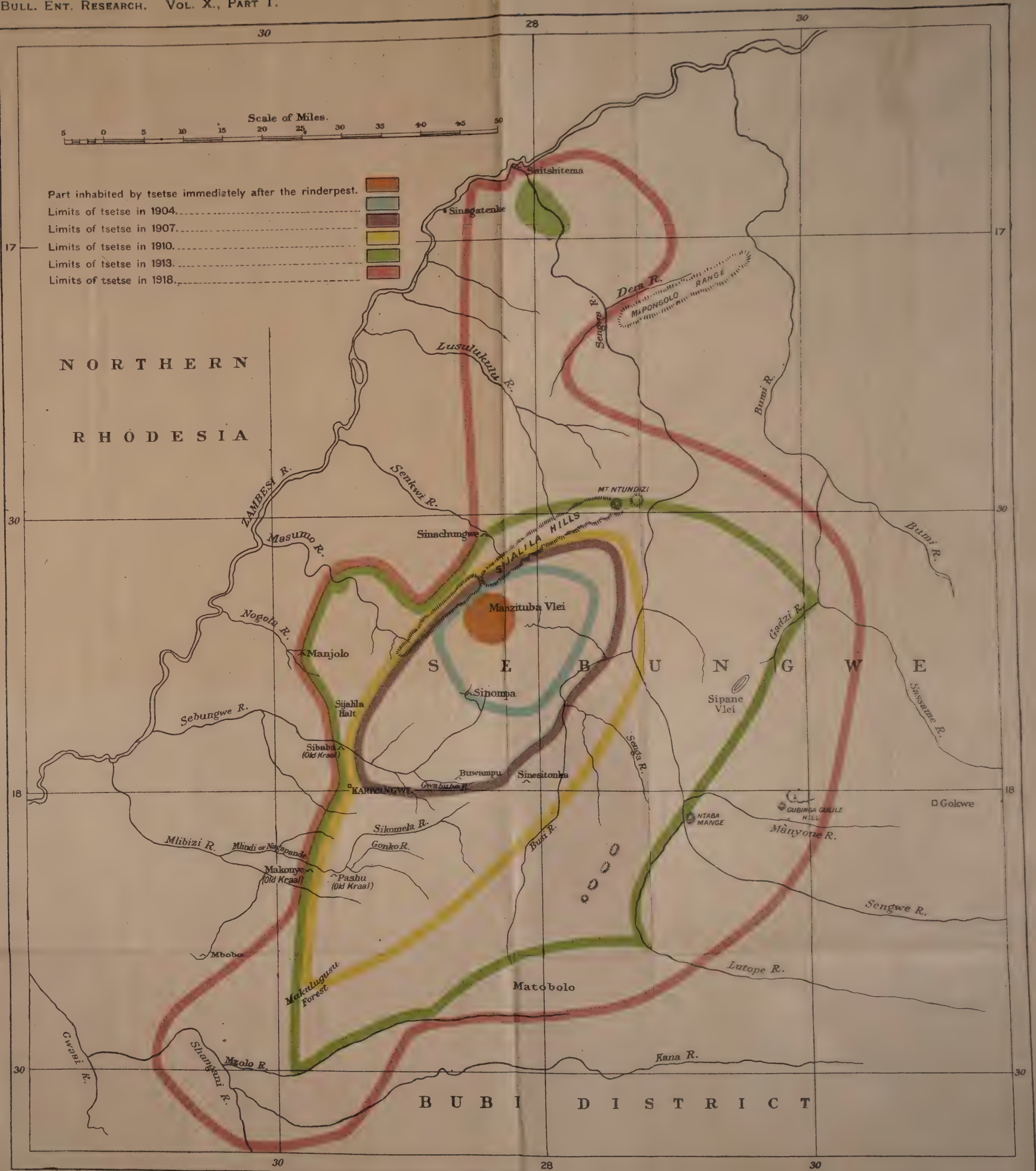


Fig. 1. Large numbers of pupæ of *Glossina morsitans* were found in a hollow in the trunk of this tree; Sipane Vlei, Southern Rhodesia, November 1914.



Fig. 2. Enlarged view of the hollow in which the *Glossina morsitans* pupæ were found.





Map showing the increase in recent years of GLOSSINA MORBITANS in the Sebungwe District.







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THE SURI-SURI FLY BELT IN THE HARTLEY DISTRICT, SOUTHERN RHODESIA.





# ON THE OCCURRENCE OF *STEGOMYIA FASCIATA* IN A HOLE IN A BEECH TREE IN EPPING FOREST.

By Captain M. E. MACGREGOR, R.A.M.C.,

*Officer in charge of the Entomological Laboratory, Sandwich, Kent.*

For the last few months I have been using a beech tree-hole in Epping Forest as a source of supply of *Anopheles plumbeus*; and it has been our custom to collect larvae from the hole and transfer them to the laboratory at Sandwich, where the development is continued under artificial conditions. In this way we have been able to obtain large numbers of *Anopheles plumbeus* and *Ochlerotatus geniculatus*, together with the recently discovered *Orthopodomyia albionensis* \* as an associate. Not long after finding the *Orthopodomyia*, I was surprised to find yet another species from the same tree-hole, two male *Stegomyia fasciata* emerging from the tank containing the mixed larvae from Epping Forest. The specimens were of normal size, and we now have them preserved in our collection here.

As is well known, *Stegomyia fasciata* has been brought to England for experimental purposes, and has been kept breeding in captivity by several workers for some years. It is therefore probably accounted for in nature in England by stray individuals which have accidentally escaped from the laboratories. It is, however, very surprising that the first recorded specimens to be found under natural conditions in England should have occurred in a forest to a large extent removed from human habitation, since *Stegomyia fasciata* abroad is essentially a domestic mosquito. The insect may therefore be indigenous.

The larvae were collected, and bred out in the laboratory, under my personal supervision, so that I can vouch for the absence of any error in the observation.



## COLLECTIONS RECEIVED.

The following collections were received by the Imperial Bureau of Entomology between 1st January and 31st March, 1919, and the thanks of the Managing Committee are tendered to the contributors for their kind assistance :—

Dr. W. M. Aders, Government Economic Biologist :—23 Diptera and 2 Lepidoptera ; from Zanzibar.

Mr. T. J. Anderson :—9 Diptera, 137 Chalcids, 267 other Hymenoptera, 3 Lepidoptera, 27 Coleoptera, a number of Coccidae, and 12 other Rhynchota ; from British East Africa.

Mr. B. N. Bandyopadhyay :—11 Culicidae, 1 Tabanid, and 1 *Glossina* ; from British East Africa.

Lieut. P. J. Barraud :—315 Culicidae, 137 Culicid larvae, 17 Culicid preparations, 44 other Diptera, 36 Slides of Siphonaptera, 5 Hymenoptera, 11 Coleoptera, 2 Coleopterous larvae, 29 Lepidoptera, 10 Orthoptera, 26 Odonata, 5 Odonate nymphs, and 2 Mites ; from Mesopotamia.

Mr. G. E. Bodkin, Government Economic Biologist :—3 Diptera, 49 Hymenoptera, 18 Coleoptera, about 30 Mallophaga, 2 species of Coccidae, 14 other Rhynchota, 8 Orthoptera, 14 Odonata, and 3 Ticks ; from British Guiana.

Capt. P. A. Buxton :—1 *Simulium*, 14 Tabanidae, 29 other Diptera, 9 Coleoptera, and 23 Rhynchota ; from Mesopotamia.

Dr. G. D. H. Carpenter :—9 Diptera, 1 Chalcid, 64 other Hymenoptera, a number of Coleoptera, 2 Planipennia, 2 Lepidoptera, 4 Cimicid bugs, 34 other Rhynchota, and 26 Orthoptera ; from Portuguese East Africa.

Mr. W. C. Crawley :—81 Coleoptera ; from Hampshire.

Mr. J. Sydney Dash :—5 Lepidoptera, 1 Hymenopteron, 31 Coleoptera, and 6 Rhynchota ; from Guadeloupe.

Mr. D. d'Emmerez de Charmoy, Government Entomologist :—17 Opiliones ; from Mauritius.

Mr. P. R. Dupont, Curator of the Botanic Station :—12 species of Coccidae and a number of fungi ; from Seychelles.

Mr. C. C. Gowdey, Government Entomologist :—2 *Tabanus*, 4 Hippoboscidae, 37 other Diptera, 10 Chalcids bred from Coccidae, 205 Hymenoptera, 34 Coleoptera, 6 Mallophaga, about 100 Aphids, 18 species of Coccidae, 30 other Rhynchota, 3 Orthoptera, 3 Ticks, and 1 Scorpion ; from Uganda.

Mr. E. Hargreaves :—212 Culicidae, 1 *Haematopota*, 47 other Diptera, 2 Hymenoptera, 19 Coleoptera, about 150 Anoplura, 27 Rhynchota, and 2 Orthoptera ; from Taranto, Italy.

Mr. J. C. Hutson :—86 Coleoptera ; from Ceylon.

Imperial Department of Agriculture :—9 Hymenoptera, and 7 Coleoptera ; from the West Indies.

Mr. Nigel K. Jardine :—278 Diptera, 38 Lepidoptera, 34 Hymenoptera, 144 Coleoptera, 29 Rhynchota, 10 Orthoptera, 9 Odonata, and 2 Arachnida ; from Ceylon.



Capt. Malcolm E. MacGregor :—4 Diptera, 3 Hymenoptera, 16 Mallophaga, about 80 Ticks, and a number of intestinal worms ; from Portuguese East Africa.

Mr. K. D. Shroff, Assistant Entomologist :—a collection of Crustacea, Mollusca and worms ; from Burma.

Mr. R. Veitch :—8 Diptera, 16 Hymenoptera, 3 Thysanoptera, 42 Coleoptera, 14 Lepidoptera, 29 Orthoptera, 7 Rhynchota, and 6 Spiders ; from Fiji and Queensland.

Capt. Jas. Waterston, R.A.M.C.:—6 *Phlebotomus*, 13 Siphonaptera, and a large number of lice ; from Macedonia.

Dr. W. G. Watt :—100 Culicidae and about 50 Culicid larvae ; from the Gold Coast.

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## THE COCCIDAE OF SOUTH AFRICA—IV.\*

By CHAS. K. BRAIN, M.Sc., M.A.,

Division of Entomology, Pretoria, South Africa.

(PLATES V–XII.)

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Genus <i>Tachardia</i> .. .. .	122
Subfamily ? .. .. .	126
Genus <i>Halimococcus</i> .. .. .	126
„ <i>Baccacoccus</i> .. .. .	127

147. *Chionaspis scutiae*, sp. n. (Plate v, fig 176).

Scale of adult ♀ about 2 mm. long, moderately broadened behind, convex, usually curved, white, not glossy, but with ± conspicuous growth-lines; exuviae orange-brown to dark brown. The colour of the second exuviae is only slightly obscured by a faint secretory covering.

Puparium of ♂ comparatively large, white, non-carinate, with yellow or orange exuviae.

Adult ♀, when mounted, regular in outline, about 1.3 mm. long, elongate, widest behind the middle, hyaline, except the median lobes which are very dense, and the middle part of the pygidium which is yellowish. The segmentation of the body is unusually distinct but is not strongly marked at the margins, nor are the abdominal segments produced.

The pygidial margin is simple. There is only one pair of lobes present, which are short and broad, densely chitinated, brown, with the rounded outer margin once notched. Plates are apparently absent, but there are two stout spines on each side. Pygidium as illustrated (fig. 176). Circumgenital glands in 5 groups:

2—4  
9—12 9—12  
14—22 14—22

*Habitat*: “Wacht-een-beetje” (*Scutia indica*, Bohn), Naauwpoort, C.P.; collected by C. P. Lounsbury, September 1907.

*Collection No.*: 182.

\*For Part II, see Bull. Ent. Res. ix, p. 107; Part III, Bull. Ent. Res. ix, p. 197.  
(C605) P4/140. 1,000. 1.20. B. & F. Ltd. G.11.



148. **Chionaspis (Pinnaspis) chionaspitiformis** (Newst.) (Plate v, fig. 175).

?*Diaspis chionaspiformis*, Newst., Bull. Ent. Res. i, p. 198, 1910.

*Hemichionaspis chionaspitiformis*, Lindinger, Jahrb. Hamb. Wiss. Anst. xxvii, Beih. 3, 1910.

Scale of adult ♀ about 2 mm. long, white, appearing very loosely constructed and soft in texture, moderately broadened behind, with yellowish or brownish exuviae. The second exuviae are covered with a thin layer of secretion.

Puparium of ♂ elongate, non-carinate, with yellow exuviae.

Some specimens collected by Claude Fuller on twigs of a native tree at Busi, Portuguese East Africa, appear as matted, dark brown to blackish scales, with brown exuviae. This, I think, is due to an accumulation of sooty fungus, as the insects agree in all other respects with those on African mahogany from Rhodesia.

Adult ♀ mounted, about 1.4 mm. long and 0.7 mm. broad at the widest point, which is situated at a considerable distance beyond the middle. The insect is narrow, rounded in front, gradually broadening to the free abdominal segments, from which it suddenly narrows to the hind extremity, which is pointed. The whole body is hyaline except the mouth-parts and median portion of the pygidium, which are yellow. The median lobes are densely chitinated and brown. The antennal tubercles are rather large with one very long flagellum and a few short spurs. Parastigmatic glands present, 5 to 8 at each anterior spiracle.

The pygidium is characterized by a single pair of lobes, which are broader than long and have their inner margins in close contact or fused; their distal end is evenly rounded and the outer margin deeply notched. From the outer edge of each lobe a short spine arises. The plates are longer and more curved than in *C. cassiae*—as illustrated in fig. 175. Circumgenital glands in 5 groups, as in *cassiae*, or with the posterior lateral glands slightly more numerous.

The most striking differences between this species and *C. cassiae* are:—that the scale is white, without the transverse brownish ridges, and the pygidium appears more acute, with the plates longer and more curved.

*Habitat*: On African mahogany, Zomba, Nyasaland; collected by Ross-Townsend, December 1908 (Cape Collection 2100). On native tree, Busi, Portuguese East Africa; collected by C. Fuller, May 1915.

*Collection No.*: 322, 322a.

149. **Chionaspis simplex**, Green, var. (Plate vi, fig. 178).

*Chionaspis simplex*, Green, Cocc. Ceylon, ii, p. 160, 1899.

Scale of adult ♀ large, 3 mm. long, and 1.5 mm. broad, broadest about middle, white, dull, without distinct growth-lines. First exuviae colourless to yellowish; second exuviae large, roundly convex, glassy, usually ± buff in colour, with a depressed median area bordered on each side by a prominent beaded ridge. In living material the second exuviae are apparently covered by a thin, dull white layer of secretion, which is easily flaked off. In the majority of dry specimens this layer and the first exuviae are missing.

Puparium of ♂ not observed.

Adult ♀♀ contain many well developed embryos with 5-jointed antennae.

Adult ♀, when mounted, elongate, narrowly rounded in front, broadest immediately behind the middle, and somewhat broadly pointed behind, hyaline, with the pygidium slightly denser; abdominal segments well marked and flatly rounded at the margin. Pygidium without lobes or plates, coarsely corrugate, with conspicuous spines and dorsal glands as illustrated (fig. 178). Circumgenital glands in 5 groups, which are often almost contiguous in a wide bow:

18—25  
24—32    24—32  
48—60    48—60

*Remarks.*—This species is very much like *C. simplex* Green, and is in all probability the variety he mentions from Mauritius; it has but 5 groups of circumgenital glands instead of 7 as in *C. simplex*.

*Habitat*: On bamboo, Durban, Natal; collected by A. Kelly, May 1915.

*Collection No.*: 175.

150. **Chionaspis caffra**, sp. n. (Plate v, fig. 174).

Scale of adult ♀ about 2 mm. long, narrow, but gradually widening to near the posterior end, where it is flattened and broadly rounded, straight or slightly curved. Exuviae brown; second exuviae covered.

♂ puparium small, white, with orange exuviae; generally non-carinate, sometimes faintly tri-carinate.

Adult ♀, mounted, about 1.4 mm. long, narrow in front, then gradually widening to some distance behind the middle; anterior part of body and median parts of the anterior abdominal segments considerably chitinised; abdominal segments not rounded, nor produced at the margin. Antennal tubercles small, each with one very stout spine.  $L_1$  close together, inner margin slanting slightly outward, crenulate.  $L_2$  small, roundly conical. Circumgenital glands in 5 groups:

5—7  
8—14    8—14  
19—25    19—25

*Habitat*: On *Acacia* sp., probably *A. caffra*, The Thorns, Pretoria; collected by C. P. Lounsbury, September 1915.

*Collection No.*: 150.

151. **Chionaspis ambiguus**, sp. n. (Plate v, fig. 177).

Scale of adult ♀ elongate, mytilaspiform, narrow in front, broadly rounded behind, usually  $\pm$  curved, arched, 2.3 mm. long, somewhat covered by outer bark tissues. Colour of scale pale to dark brown, with a greyish surface covering; exuviae yellow.

♂ puparium not observed.

Body of adult ♀ elongate, broadest just behind middle, anterior end tapering slightly and broadly rounded in front, posterior end tapering abruptly to the two densely chitinous median lobes. These, together with the chitinous thickenings extending into the pygidium, and the mouth-parts, are yellowish; remainder of body hyaline. Free abdominal segments (4) slightly rounded, not much produced. Antennal tubercles moderately large, with two stout spines. Parastigmatic glands 0.

Pygidium (fig. 177) with one pair of lobes, which are close together on their inner surface, their outer edges being crenulate. Between the median lobes there are two large spines but no plates. At the outer margins there is also a large spine, then a gland from which arises a small sharply pointed plate, then a very small rudimentary lobe, which is pointed and chitinous and in some cases seems to be composed of two lobules of which the outer is the smaller. These are followed by a long simple dagger-shaped plate, then a large gland opening and another plate. Beyond this the margin appears thickened like a minute rudimentary lobe, beyond which there are two additional pairs of plates. There are a few plates on the margin of the first abdominal segment from the pygidium in addition to the glands. Extending into the pygidium are three pairs of chitinous thickenings. Circumgenital glands in 5 groups, of which the median and anterior laterals are often almost united into a bow.

7—11  
10—14    10—14  
6—9      6—9

*Remarks.* A large percentage of the ♀ scales showed the circular exit holes of some Hymenopterous parasite.

*Habitat :* On twigs of lilac, Fort Beaufort, C.P.; collected by C.P. Lounsbury, June 1913.

*Collection No. :* 263.

152. **Chionaspis leucadendri**, sp. n. (Plate v, figs. 166, 171).

Scale of adult ♀ about 2.6 mm. long, white, smooth, slightly glossy, not very convex, long and narrow, somewhat widened and flattened behind. Exuviae brownish; second exuviae covered by a very thin layer of secretion.

♀ scales chiefly on stems; ♂ puparia most common on leaves.

♂ puparium comparatively large, white, flat, slightly roughened, not carinated, with pale exuviae, which are sometimes ± greenish yellow in colour.

Adult ♀, mounted, about 1.4 mm. long, narrow in front, but quickly widening to about middle, whence it gradually narrows again to the median lobes. Abdominal segments well indicated but not prominently produced. Body moderately chitinated, the mouth-parts, lobes, and margin of pygidium denser. The four abdominal segments adjoining the pygidium have their margins with a few gland-pores and a number of short, stout, very acute spine-glands. These, seen in optical section, appear like rose-spines, but the points are often long, slender and curved. They occur chiefly on the margin, but extend in scattered formation some distance within the edge.

P<sub>1</sub> small, spine-like. L<sub>1</sub> rounded, striate, arising from the thickened margin of the pygidium. P<sub>2</sub>—6 long, dagger-shaped. Circumgenital glands in 5 groups, which are almost contiguous, in the form of a horse-shoe:

4—7  
11—18    11—18  
26—32    26—32

*Habitat :* On silver-leaf tree (*Leucadendron argenteum*), National Botanic Gardens, Kirstenbosch, Capetown; collected by the late Professor H. H. W. Pearson, August 1914.

*Collection No. :* 145.

153. **Chionaspis (Phenacaspis) lounsburyi**, Cooley (Plate v, fig. 169).*Chionaspis lounsburyi*, Cooley, Can. Ent. xx, p. 87, 1898.*Phenacaspis lounsburyi*, Fernald, Catalogue, p. 238, 1903.

Adult ♀ scale about 3 mm. long, white, glossy and pearly, sides almost parallel when at the margin of a leaf, but usually broadened behind the middle when on the blade; evenly rounded behind, often with faint transverse ridges. Ventral scale absent or represented only by the incurved margins of the dorsal scale and an extremely delicate layer which remains on the leaf. Exuviae orange-yellow or orange-brown; first exuviae paler, second covered by a pearly white layer of secretion.

♂ puparium about 1 mm. long, similar to that of ♀ but smaller, non-carinated.

Body of the adult ♀ elongate, all colourless and hyaline, except the mouth-parts and lobes which are faintly yellow. The free abdominal segments are not produced at the margin, but are slightly rounded.

L<sub>1</sub> low, broad, and very widely divergent, usually appearing as though they projected from behind the thickened median area of the pygidium. L<sub>2</sub> composed of two small lobules which are distinctly separated; the inner lobule is the larger. Lobes distinctly striate. Plates simple, thin.

The antennae are placed a long way back near the mouth-parts and consist of minute tubercles each with one long thin curved hair. Parastigmatic glands present, usually 3 to 5 at anterior spiracles. Circumgenital glands in 5 groups:

4—7	
11—15	11—15
20—26	20—26

*Habitat*: On *Rhus thunbergi*, Ceres, C.P.; collected by C. P. Lounsbury, 1896. On a native Proteaceous plant, Wolseley, C.P.; collected by C. P. Lounsbury, June 1915.

*Collection Nos.*: 166, 170.

153a. **Chionaspis (Phenacaspis) lounsburyi ekebergiae**, var. n. (Plate v, fig. 168).

♀ scale similar to that of *C. lounsburyi*, but readily distinguished by the following characters:—

Parastigmatic glands present, 5 or 6 glands in a close crescent. Pygidial margin as figured (fig. 168). Circumgenital glands more numerous, *e.g.*,

6—9	
11—20	11—20
29—46	29—46

Plates more distinct and last row of dorsal glands more numerous than in *C. lounsburyi*, usually 9:4.

*Habitat*: On *Ekebergia* sp., Durban; collected by C. Fuller, July 1915.

*Collection No.*: B. 186.



154. **Chionaspis (Phenacaspis) natalensis**, Ckll. (Plate v, fig. 165).

*Phenacaspis natalensis*, Ckll., Ann. Mag. N.H. (7) ix, p. 25, 1902.

*Phenacaspis natalensis*, Fernald, Catalogue, p. 238, 1903.

Professor Cockerell's description is as follows :—

"♀ scale white, about 3 mm. long, pyriform; exuviae pale orange-brown.

"Five groups of circumgenital glands; median of 10, anterior laterals 22-26, posterior laterals 19-26. Anal and genital apertures opposite. Median lobes large, widely diverging, broader than long, the long inner margin strongly serrulate; their bases well apart, the space occupied by the usual pair of short spines. Second lobe represented by three elongated and rounded lobules, the first of which is largest and bears a spine. Third lobe represented by a very long narrow lobule bearing a spine followed by a broad and much shorter lobule, and then a very broad serrulate lobule, having its outer slope much the longest. The fourth lobe is represented by a triangular lobule bearing a spine and two slight swellings of the margin, too slight to be called lobules.

"♀ scale feebly tricarinate or barely keeled at all."

*Habitat*: On mango, Durban, Natal; collected by C. Fuller, 1901. On palm, Durban; collected by A. Kelly, July 1915.

*Collection Nos.*: 171, 171a.

155. **Chionaspis (Dinaspis) imbricata**, sp.n. (Plate vi, fig. 179).

In material seen by the writer the scales invariably occupy cracks in the bark on the stems of the host-plant.

Scale of adult ♀ small, elongate, almost parallel-sided, white, with orange to brown exuviae.

Puparium of ♂ similar but smaller.

Adult ♀, when cleared and mounted, small, averaging 0.75 mm. long and 0.48 mm. broad. The anterior end is broadly rounded; the sides of the body are almost parallel to a little more than half the length, when they gradually taper to the pointed pygidium. The anterior half of the body and the pygidial area are more densely chitinated than are the free abdominal segments and appear yellowish. The chitin on these parts is thickened in minute ridges, giving the impression of a finger-print, a character only found in a few Coccids.

It is impossible to describe the pygidial margin as having definite lobes, and plates are absent. The chitin is here folded so as to form numerous rounded more or less imbricated prominences, some of which reach, or extend beyond, the margin, which thus appears festooned. There are a few spines of moderate length at intervals around the margin. The anal opening is set well back from the margin and around it are a number of conspicuous thin spots in the chitin, appearing as perforations. In the second stage ♀ there are about three simple plates on each side of the pygidium.

Antennae set well forward, tubercles moderately prominent with one or two curved setae. Parastigmatic glands O. Circumgenital glands O.

*Habitat*: On stems of *Euclea natalensis*, Point Road, Durban; collected by C. P. v. d. Merwe, July 1916.

*Collection No.*: 157.

156. **Chionaspis (Dinaspis) diosmae**, sp. n. (Plate v, fig. 167).

Insects  $\pm$  clustered on leaves of host-plant, especially on the upper surface.

Adult ♀ scale about 2.2 mm. long, comparatively broad, moderately convex, silky in appearance, with conspicuous growth lines. First exuviae yellow; second exuviae brownish, covered by a dense layer of secretion similar to remainder of scale. The layer covering the second exuviae is very easily removed and carries the small first exuviae with it. Owing to this fact many of the specimens appear to have brownish, shining pellicles.

Adult ♀ viviparous; mounted specimens contain many well-developed larvae.

Adult ♀, mounted, about 1.6 mm. long and 0.8 mm. broad; widest about middle and narrowing to each end. Body moderately chitinated. The pygidial margin is quite different from that of any other species of *Dinaspis* known to me. The median notch is angular, with narrow straight thickened margins, below which the median lobes project. Owing to this fact the appearance of the lobes varies greatly according to how the specimens are mounted,  $L_1$  in some cases appearing quite distinctly, in others being almost invisible. There are apparently no plates. Pygidium as illustrated (fig. 167). Circumgenital glands O.

*Habitat*: On buchu (*Diosma crenata*), Wellington, C. P.; collected by C. P. v. d. Merwe, November 1904 (Cape No. : 1554).

*Collection No.* : 147.

157. **Chionaspis (Dinaspis) lounsburyi** (Leonardi) (Plate v, fig. 172).

*Dinaspis lounsburyi*, Leon., Bol. R. Sc. Agr. Portici, p. 216, 1914.

*Chionaspis capensis*, Newst., Bull. Ent. Res. vii, p. 378, 1917.

Scale of adult ♀ about 2 mm. long, elongate, generally straight, but varying in shape according to the position on the plant, condition of crowding, etc. On straight stems the sides of the scale are  $\pm$  parallel from the end of the second exuviae to beyond the middle, where it becomes slightly broadened with the hind margin broadly rounded. Other specimens situated in the angles of thorns, etc., are much shorter and broader, sometimes almost as broad as long. Colour of scale white; first exuviae bronze to bronze-brown; second exuviae brown, slightly pointed behind.

Puparium of ♂ about 0.8 mm. long, white, non-carinated, with orange pellicles. Posterior margin of puparium broadly rounded, opening by the upper part splitting from the lower so that the dorsal flap is exactly like the lower one.

Adult ♀ viviparous; when mounted, elongate. Anterior part suddenly narrowed and rounded in front, paler yellow; median portion of body darker yellow, wider, with almost parallel sides; posterior extremity broadly rounded. The free abdominal segments are broadly rounded at the margins. Antennal tubercle small, with two setae of medium length and thickness. Pygidium as illustrated (fig. 172). Circumgenital glands O.

*Habitat*: On stems and leaves of native spiny plant (*Gymnospora buxifolia*); extremely common around Pretoria and also received from Umtali, Rhodesia (sent by R. Lowe Thompson, of Salisbury).

*Collection No.* : 251.

158. **Chionaspis (Dinaspis) distincta** (Leonardi) (Plate v, fig. 170).

*Dinaspis distincta*, Leonardi, Bol. Sc. R. Agr. Portici, p. 213, fig. 33, 1914.

*Chionaspis distorta*, Newst., Bull. Ent. Res. vii, p. 377, 1917.

Scale of adult ♀ about 2.2 mm. long, moderately broad, convex and roughened, dull white or greyish white in colour, with exuviae dark orange-brown; second exuviae covered.

Puparium of ♂ robust, buff-coloured and non-carinate, with yellowish or orange exuviae. Very few ♂ specimens are present in the large amount of material before me and in a number of cases the ♂ puparium does not lie close to the stem in the usual manner, but seems to be attached at the anterior end and projects outward between several female scales.

Adult ♀ viviparous; elongate, narrow in front, gradually broadening to behind the middle, to which point the body is highly chitinated; posterior to this it is thin, hyaline. There are three pairs of lobes, which are more heavily chitinated than the remainder of the pygidium:  $L_1$  broad, inner margins converging at the base, faintly trilobed or broadly crenulate; median lobe small,  $L_2$  and  $L_3$  small,  $\pm$  triangular. Antennae with one long flagellum and four short stout spurs. Circumgenital glands O.

*Habitat*: On stems of *Protea hirta*, Pretoria; collected by the writer, October 1914. Professor Newstead's reference "Windersboom, Transvaal," should be Wonderboom, Pretoria.

*Collection No.*: 163.

159. **Chionaspis (Poliaspis) carissae** (Ckll.) (Plate v, fig. 164).

*Poliaspis carissae*, Ckll., The Entom. xxxv, p. 112, 1902; Fernald, Catalogue, p. 243, 1903.

Scale of adult ♀ about 1.8 to 2 mm. long, usually straight, widest shortly behind the second exuviae and somewhat abruptly narrowed and attenuated posteriorly; white, glossy, with brown exuviae.

Puparium of ♂ white, very long, distinctly tri-carinate; exuviae almost colourless.

Specimens on "umkavoti" at Durban had the ♀ scales faintly marked by transverse ridges and the ♂ puparia with a pronounced median ridge.

The body of the adult ♀ is long, narrow in front, then almost parallel-sided to the free abdominal segments, with the posterior margin regularly and broadly rounded. The median portion of the body is highly chitinated and appears brownish-yellow in mounted specimens. The anterior end is paler in colour, and the free abdominal segments and the pygidium are almost colourless. Circumgenital glands in 8 groups:

3—4	3—4	3—4
11—17	2—4	11—17
17—27		17—27

*Remarks.* Professor Cockerell's original description is as follows:—

"♀ scale similar to that of *P. cycadis*, but perhaps narrower. Second skin paler, as in *cycadis*.

"♀ similar to *P. cycadis*, but the strongly serrulate reddish-brown median lobes are wide apart, the interval being nearly as great as the breadth of a lobe; the second lobe consists of two lobules, of which the inner is the larger, and its tip projects a little

beyond the level of the tips of the median lobes ; the margin just beyond the second lobe bears two large dorsal glands, like those of the series on the next segments anteriorly ; there are only four dorsal glands in the short rows nearest the anal orifice. The middle of the body is red-brown, and strongly chitinised. Circumgenital glands in eight groups ; the posterior laterals 19, middle laterals (cephalolaterals of other genera) 11, median 5, in a transverse row, and the anterior groups characteristic of *Poliaspis* form a transverse series broken into three linear groups of three or four, which are widely separated.

“ ♂ scale tricarinate.

“ On *Carissa* (? *C. grandiflora*, D.C.) plant, which belongs to the Apocynaceae, Durban, Natal (Fuller). In these species and *P. cycadis* the anterior group of glands are in transverse lines ; in *P. media*, and the species described by Fuller from Australia, the groups are circular.”

*Habitat* : On *Carissa grandiflora* (amatingula), Durban ; collected by C. Fuller (part of original material). On “unkavoti” (*Chaetachme aristata*), Durban ; collected by C. Fuller, October 1914.

*Collection Nos.* : 181 and 167.

160. **Chionaspis (Pinnaspis) cyanogena** (Ckll.) (Plate vi, fig. 180).

*Hemichionaspis cyanogena*, Ckll., The Entom. xxxiv, p. 226, 1901 ; Fernald, Catalogue, p. 240, 1903.

Scale of adult ♀ about 2 mm. long, narrow, moderately convex, white, but appearing slightly greyish in massed specimens. Exuviae pale yellow to orange ; second exuviae covered by a thin secretory layer which is easily flaked off and therefore often missing.

Puparium of ♂ white, non-carinate, or with a distinct median ridge. Exuviae pale yellowish.

The body of the ♀ is elongate, often rather narrow in front and suddenly broadening to about the middle and suddenly narrowing again to the pointed pygidium. The margins of the free abdominal segments are not conspicuously produced, but are supplied with numerous gland-openings and a few short, pointed projections. The pygidium has the median lobes moderately produced, their inner margins straight and in close contact, their outer extremities sloping gently backward and twice notched, forming three sub-equal rounded crenulations. The median lobes and the posterior median part of the pygidial area are yellow, and the yellowish coloured spots on the margin may indicate three other pairs of rudimentary lobes. At these points gland-openings are apparent, and small rounded projections may be seen on the margin ; the plates are a little longer than the median lobes and are distributed as shown in fig. 180. Antennal tubercles ± globular, with one curved flagellum. Circumgenital glands in 5 large groups :

12—18  
15—19   15—19  
13—17   13—17

*Habitat* : On *Alternanthera sessilis*, R. Br., Durban ; collected by C. Fuller. On *Alternanthera sessilis*, R. Br., Scottsburg, and on native weed, Natal coast ; collected by C. Fuller, July 1915.

*Collection Nos.* : 177 and 177a.



161. **Chionaspis (Pinnaspis) aspidistrae**, Sign. (Plate vi, fig. 181).*Chionaspis aspidistrae*, Sign., Ann. Soc. Ent. Fr. (4) ix, p. 443, 1869.*Chionaspis brasiliensis*, Sign., Ann. Soc. Ent. Fr. (4) ix, p. 444, 1869.*Chionaspis latus*, Ckll., Psyche, vii, Suppl. 1, p. 21, 1896.*Chionaspis aspidistrae*, Green, Cocc. Ceylon, ii, p. 110, 1899.*Hemichionaspis aspidistrae*, Cooley, Spec. Bull. Mass. Exp. Sta. p. 45, 1899.*Chionaspis aspidistrae*, Newst., Mon. Brit. Cocc. i, p. 187, 1901.*Hemichionaspis aspidistrae*, Fernald, Catalogue, p. 239, 1903.*Pinnaspis aspidistrae*, Lindinger, Die Schildläuse, p. 79, 1912.

Scale of adult ♀ variable, largest specimens about 2.5 mm. long, more or less pear-shaped, thin, usually semi-transparent, whitish or yellowish to reddish brown. Exuviae colourless or faintly yellow.

Adult ♀ elongate, broadest across the abdominal segments, which have the margins produced into rounded conical processes in the young adult stage. Pygidium as illustrated (fig. 181). Circumgenital glands in 5 groups :

5—15

15—23    15—23

17—23    17—23

*Habitat* : On ferns, *Aspidistra*, etc., Cape, Natal, and Transvaal.*Collection No.* : 176.162. **Chionaspis (Pinnaspis) proxima** (Leonardi).*Hemichionaspis proxima*, Leon., Bol. R. Sc. Agr. Portici, p. 193, 1914.

A translation of Professor Leonardi's description is as follows :—

"Female. Body elongate, with the extremity rounded and having the greatest width about the middle. The abdominal segments narrower than the cephalothorax and projecting laterally in well defined lobes, which have their free margins rounded. The lobes of the last abdominal segments have 2-3 long and robust hairs along the free margin. The buccal apparatus with the maxillary-mandibular bristles radiating and extending beyond the posterior extremity of the body.

"Antennae tuberculiform and surmounted with a long flagellum. Posterior stigmata without glands.

"Pygidium with two pairs of lobes, of which the middle pair, which is deeply coloured, has the inner margins approximated and the outer more deeply incised. Those of the second pair are separated from the first by a robust hair, and by the mouth of a large wax-gland. They are very small, slender, somewhat hyaline, with the free margin rounded and entire. On the outer side of each of the second lobes there is first a hair, then the mouths of two large wax-glands, and at a certain distance from these another hair followed by the mouths of two other wax-glands, and lastly near the pre-anal segment a fourth hair.

"The circumgenital glands are in five groups, *e.g.*,

10		8		12	
21	19	17	19	15	21
17	17	16	16	22	23

"The sexual aperture is situated in the middle of four groups of lateral glands. The anal aperture is almost the same height as the sexual opening, but rather more towards the pre-anal segments.

"Colour of the body in specimens treated with acetic acid, yellowish, except the pygidium which is yellow-ochraceous.

"Female scale. Oval, flatly convex, with the secreted portions scant, whitish grey, and the exuviae at the apex and narrower than the scale, and of an ochroleucous colour.

"Dimensions of the scale :

Length of scale	..	..	..	..	..	1,280 $\mu$
Width of scale	..	..	..	..	..	800 $\mu$
Length of larval exuviae	..	..	..	..	..	350 $\mu$
Width of larval exuviae	..	..	..	..	..	220 $\mu$
Length of nymphal exuviae	..	..	..	..	..	750 $\mu$
Width of nymphal exuviae	..	..	..	..	..	470 $\mu$

"Male scale. Elongate, sides parallel, straight or slightly curved, rounded behind, with the dorsum deeply grooved, and the resulting ridges well marked. Larval exuviae yellowish, small and situated at one end. Waxy scale white. Size of scale : length 960 $\mu$  ; width 320 $\mu$ .

"Habitat: Collected at Thies (Senegal) and at Mamu on mango, at Konakry on *Anona*, at Hann (Dakar) on *Calotropis procera* and on an undetermined plant ; at Dodowa, at Lagos, at Cotonou (Dahomey), at Quifangando (Angola) and at Pretoria on undetermined plants.

"Notes: This species is near *Hem. orlandi*, Leon., from which it can readily be distinguished by the following characters. It has glands at the anterior stigmata and the glands around the sexual aperture are always more numerous ; there are present, although not very apparent, a second pair of lobes, and further, the last four abdominal segments are supplied with hairs, not only the last two as is the case in *Hem. orlandi*."

This species is not represented in this collection and although a thorough search has been made around Pretoria it has not been found by the writer.

Habitat : On an undetermined plant, Pretoria ; collected by Professor Silvestri.

Collection No. : 178.

#### Genus **Lepidosaphes**, Shimer.

*Lepidosaphes*, Shimer, Tr. Am. Ent. Soc. i, p. 373, 1868.

*Mytilaspis*, Sign., Ann. Soc. Ent. Fr. (4) viii, p. 841, 1868 (no description).

*Mytilaspis*, Sign., Ann. Soc. Ent. Fr. (4) x, p. 91, 1870.

Scale of adult ♀ elongate, usually narrowed in front and gradually broadening behind. The colour is very variable, but often orange-brown to dark brown. The exuviae are terminal, with the second exuviae covered. The female scales are usually  $\pm$  curved. Ventral scale variable, similar to those of *Chionaspis* spp.

The ♂ puparium is similar to that of the ♀, but smaller and narrower ; the larval exuviae are terminal. The posterior part of the puparium is often separated by a thin transverse band of secretion, which acts as a hinge, allowing the extremity of the scale to be raised to permit the adult ♂ to emerge.

Adult ♀ elongate, with the margins of some of the segments often produced. Circumgenital glands in 5 groups, but each group usually consisting of fewer glands than is normal in *Chionaspis*.

163. **Lepidosaphes pinnaeformis** (Bouché) Kirk. (Plate vi, fig. 183).

*Aspidiotus pinnaeformis*, Bouché, Stett. Ent. Zeit. xii, p. 111, 1851.

*Coccus beckii*, Newm., The Entom. iv, p. 217, 1869.

*Aspidiotus citricola*, Pack., Guide to Study of Insects, p. 527, 1869.

*Mytilaspis fulva*, Targ., Bol. Soc. Ent. Ital. p. 131, 1872.

*Mytilaspis flavescens*, Targ., Ann. R. Min. Agr. p. 84, 1876.

*Mytilaspis citricola*, Comst., Rept. U. S. Dept. Agr. p. 321, 1881.

*Mytilaspis citricola*, Lounsbury, Rept. Ent. C. G. H. p. 67, 1896.

*Mytilaspis citricola*, Green, Cocc. Ceylon. i, p. 78, 1896.

*Mytilaspis pinnaeformis*, Newst., Mon. Brit. Coccidae, i, p. 204, 1901.

*Mytilaspis beckii*, Ckll., Ent. News, xiii, p. 17, 1902.

*Lepidosaphes pinnaeformis*, Kirkaldy, Fauna Haw. iii, 2, p. 110, 1902.

*Lepidosaphes pinnaeformis*, Fernald, Catalogue, p. 313, 1903.

*Lepidosaphes beckii*, Fernald, Catalogue, p. 305, 1903.

Common Name : Mussel Scale.

Scale of adult ♀ elongate, usually  $\pm$  curved, narrow in front and broadened behind, with a flattened paler marginal area. Colour varying greatly with host-plant, etc., from pale greyish or yellowish brown to reddish- or olivaceous-brown. In size it may reach 3 mm. long and nearly 1 mm. in breadth.

The ♀ puparium smaller, narrower, and more delicate in texture, with sides  $\pm$  parallel, and colour usually a little paler.

Adult ♀ elongate, narrow in front, widest at the first free abdominal segment, *i.e.*, behind the middle. The colour is generally whitish, or faintly yellowish with the terminal segments darker. The antennae are represented by a small tubercle with two stout curved hairs. The pygidium as illustrated (fig. 183). Circumgenital glands in 5 groups :

5—8  
9—17    9—17  
7—11    7—11

*Habitat* : On croton, Capetown, Port Elizabeth, and Uitenhage (C.P.), Johannesburg (Tr.), and Durban (Natal). On orange, Cape Province, Natal and Transvaal. On *Muraya*, New Guelderland, Natal.

*Collection Nos.* : 262–262e.

164. **Lepidosaphes gloveri** (Pack.) Kirk. (Plate vi, fig. 182).

*Coccus gloveri*, Packard, Guide to Study of Insects, Ed. i, p. 527, 1869.

*Mytilaspis flava*, Targ., Catalogue, p. 44, 1869.

*Mytilaspis gloverii*, Comst., Rept. U. S. Dept. Agr. p. 323, 1881.

*Mytilaspis gloverii*, Lounsbury, Rept. Ent. C. G. H. p. 71, 1896.

*Mytilaspis pallida*, Green, Ind. Mus. Notes, iv, p. 5, 1896.

*Mytilaspis gloverii* var. *pallida*, Green, Cocc. Ceylon, i, p. 85, 1896.

*Lepidosaphes gloveri*, Kirkaldy, Fauna Haw. Is, iii, 2, p. 111, 1902.

*Lepidosaphes gloverii*, Fernald, Catalogue, p. 309, 1903.

*Lepidosaphes gloveri*, Lind., Die Schildläuse, p. 106, 1912.

Common Name : Long Scale.

The scale of the adult ♀ is very long and narrow, 2·5 to 3 mm. long and about 0·5 mm. broad, long comma-shaped, usually reddish or greyish-brown with paler margins : on some host-plants the colour is paler. Exuviae terminal, yellowish. Ventral scale well developed, whitish.

♂ puparium much smaller and more delicate than the ♀ scale, and paler in colour.

Adult ♀ elongate, sides ± parallel, abdominal segments slightly wider, but without prominent lateral projections. The colour when alive is pale yellow. Pygidium as illustrated (fig. 182). Circumgenital glands in 5 groups :

$$\begin{array}{cc} & 4 \\ 6-8 & 6-3 \\ 4-5 & 4-5 \end{array}$$

*Habitat* : On citrus, Cape Peninsula ; collected by C. P. Lounsbury. Also at Port St. Johns, Stanger, and Warmbaths.

*Collection No.* : 261.

#### Genus *Ischnaspis*, Douglas.

Female scale extremely long and narrow, with the first exuviae extending beyond the anterior margin. Male puparium elongate, similar to that of the second stage female, without the central hinge of the ♂ of *Lepidosaphes*.

Adult ♀ very long and narrow, posterior margin of pygidium forming a regular shallow concave depression, from which the median lobes project. Dorsal surface of pygidium with a peculiar lattice-work design. Circumgenital glands in 3 or 5 small groups.

#### 165. *Ischnaspis longirostris* (Sign.) (Plate vi, fig. 184).

*Mytilaspis longirostris*, Sign., Bull. Soc. Ent. Fr. (6) ii, p. xxxv, 1882.

*Ischnaspis filiformis*, Douglas, Ent. Mo. Mag. xxiv, p. 21, 1887.

*Ischnaspis filiformis*, Newst., Mon. Brit. Coc. i, p. 210, 1901.

Common Name : Black Thread Scale.

Scale of adult ♀ 3 to 3·5 mm. long, very narrow, with sides parallel ; posterior extremity slightly broader ; colour shining black, with greyish margins. Scale very convex, often showing slight indications of transverse ridges, usually straight, but where a number are crowded together the scales often make a regular bend to avoid other scales and then continue again in the original direction. Larval exuviae terminal, brownish in colour ; second exuviae occupying about one-quarter of the length of adult scale, covered with shiny black secretion like the remainder of the scale. Ventral scale complete, robust, white or greyish in colour.

Adult ♀ very long, sides parallel, broadest at the free abdominal segments. Colour yellow. Pygidium as illustrated (fig. 184). Circumgenital glands in 3 groups :

$$\begin{array}{cc} 3-4 \\ 4-6 & 4-6 \end{array}$$

A few large (to 4 mm. long) specimens in the Cape collection, otherwise typical, have 5 groups of glands. Three of these have :

$$\begin{array}{ccccc} & 4 & & 5 & & 4 \\ 7 & 7 & 7 & 6 & 7 & 7 \\ 5 & 5 & 3 & 4 & 3 & 3 \end{array}$$



*Habitat*: On citrus, Warmbaths (Tvl.). On *Chaetachme aristata* (umkavoti), Durban, Natal; palms, East London, Durban and Pretoria; *Aucuba*, East London. On *Dracaena australis*, East London; collected by C.P. Lounsbury, November 1906.

This species is particularly abundant on citrus at Warmbaths, Transvaal.

*Collection Nos.*: 277-277b and 278.

#### Subfamily ASTEROLECANIINAE.

Adult females fixed to the stem of their host-plants; sometimes causing pits in the stems and thus becoming slightly or almost entirely embedded in the outer tissues. Adults usually enclosed in a more or less horny or glassy cyst, which is most often yellow in colour and, in one genus, has a marginal fringe of glassy filaments. The legs and antennae are most often rudimentary or absent in the adult stage. Figure-8 glands are present in one or more stages.

This subfamily is represented in South Africa by four genera which may be distinguished as follows:—

Test of ♀ usually yellowish, ± transparent, with marginal fringe ..	<i>Asterolecanium</i> .
Test of ♀ dense, almost ligneous, without fringe .. ..	<i>Lecaniodiaspis</i> .
Test of ♀ ± waxy and without fringe, ♀ without stigmatic spines ..	<i>Cerococcus</i> .
♀ naked, causing shallow rounded galls in stem* .. ..	<i>Amorphococcus</i> .

#### Genus *Asterolecanium*, Targioni-Tozzetti.

*Asterolecanium*, Targ., Inter. 2nd Mem. Studi Cocc. Catalogue, p. 41, 1869; Sign., Ann. Soc. Ent. Fr. (4) x, p. 276, 1870.

*Planchonia*, Sign., Ann. Soc. Ent. Fr. (4) x, p. 282, 1870.

*Asterodiaspis*, Sign., Bull. Soc. Ent. Fr. (5) vi, p. ccix, 1876.

“Female insect completely enclosed within a thin but compact glassy or horny test, characterised by a continuous marginal fringe of glassy filaments. The test may be hemispherical, flat, or even somewhat concave above. It varies in outline from circular to linear. The surface is usually smooth, with, in some species, erect or curling filaments on the disc, similar to those of the marginal series. . . . At the posterior extremity there is a small opening through which the larvae escape. This aperture is sometimes placed at the end of a tubular extension, which is often more or less elevated. The colour of the test is invariably of a greenish or yellowish tint, but the fringe and dorsal filaments are sometimes tinged with red. . . .

“The adult female insect, denuded of its covering, is at first approximately of the same form as its covering. After oviposition it shrivels up and lies at the anterior extremity of the test, the remaining cavity being packed with ova. The antennae are rudimentary, consisting of a single short joint with a few curved hairs at its extremity. The limbs are totally absent. . . . No stigmatic spines. Anal lobes absent or minute, usually represented by a pair of small tubercles and each bearing a stout seta. In a few species, both tubercles and setae are wanting. Between the setiferous tubercles are usually from two to four smaller tubercles, each bearing a small spine. The anal ring is sunk in a tubular pit which sometimes opens on to the extreme margin, but usually terminates shortly before the margin on the dorsal surface; it normally carries six stout hairs, but is sometimes hairless. . . .

\* See Bull. Ent. Res. ix, p. 112.

"Male puparium of similar structure to that of the female, but smaller and proportionately narrower. The fringe is simpler, consisting only of the nymphal and larval elements. The winged adult emerges from beneath the posterior margin without the aid of any hinged operculum such as occurs in the allied genus *Lecaniodiaspis*.

"Adult male with distinct neck. Antennae ten-jointed, with three or four knobbed hairs at apex. Ocelli large, in two pairs—dorso-lateral and ventral respectively. Rudimentary eyes small, colourless and inconspicuous. Scutellum ample. Halteres absent or obscure. Genital sheath long and sharply pointed. Two long caudal filaments.

"Larva of typical form. Antennae distinctly six-jointed. A marginal series of (usually twenty-eight) paired glands. Posterior extremity with a pair of longish caudal setae" . . . (Green).

*Key to South African Species of Asterolecanium.*

A. Anal ring hairless.

a. Antennae rudimentary.

Anal extremity of test turned up, tubular ; caudal setae of adult ♀ short, stout  
*brevispinum*, sp. n.

Anal extremity of test not prominently upturned or tubular ; caudal setae long  
*variolosum*, Ratz.

aa. Antennae long, 10-jointed, caudal setae long . . . . *borboniae*, sp. n.

AA. Anal ring large, with 6 long spine-like hairs.

a. Marginal fringe of adult test reddish.

Test small, flattish, usually naked when old . . . . *pustulans*, Ckll.

Test small, flat ; on acacia . . . . *conspicuum*, sp. n.

Test large, rounded ; on bamboo . . . . *bambusae*, Boisd.

aa. Marginal fringe of adult test white.

Test yellow, globular, enveloped in very long fringe . . . . *euryopsis*, Fuller.

Test greenish or creamy white, fringe short . . . . *stentae*, sp. n.

166. ***Asterolecanium brevispinum***, sp. n. (Plate vii, fig. 188 ; Plate viii, fig. 197).

Test of adult ♀ about 3 mm. long, 2.2 mm. broad, very convex, with the caudal extremity produced into a narrow upturned process. The colour is bright yellow and somewhat transparent, except at the anterior end which is bright brown in the few specimens at hand, probably owing to the presence of the shrivelled female body. Of the eight specimens in this collection five of the tests are entirely naked. The other three show the presence of long large curved glassy filaments (fig. 188), which were apparently equally long and equally numerous over the whole dorsal and marginal areas. The integument of the body is very thin ; the antennae are small, ± cordate, with two short spurs. The caudal extremity is simple, with a small hairless anal ring ; the caudal setae are represented by short stout spines. The figure-8 glands are comparatively large (fig. 197).

*Remarks.* This species is somewhat like *A. coffeae*, Newst., but the fringe is white instead of yellow, and there are other distinctive differences to be seen in the mounted specimens, particularly the hairless anal ring and short caudal spines.

*Habitat* : On veld bush, Ceres, C. P. ; collected by C. P. Lounsbury, October 1908.

*Collection No.* : 21.

167. **Asterolecanium variolosum**, Ratz. (Plate vii, fig. 190 ; Plate viii, fig. 193).

*Asterolecanium quercicola*, Sign. et Auctt. (nec *Lecanium quercicola*, Bouché).

*Coccus variolosus*, Ratz., Tharander Jahrbuch, xx, p. 187, 1870 (not seen ; *vide* Judeich & Nitsche).

*Lecanium quercus*, Altum (nec Linné), Forstzoologie, iii, Insecten, p. 365, 1881.

*Coccus variolosus*, "Ratzeburg MS.," Hagen, Can. Ent. xix, p. 60, 1887 (no description).

*Planchonia fimbriata* (Boyer) Maskell, Extract, Trans. N. Z. Inst., 1894, p. 63.

*Coccus quercicola*, Sign., Judeich & Nitsche, Lehrb. Mitth. Forstins., ii, p. 1252, 1895.

*Planchonia quercicola* (Bouché) Maskell, Trans. N. Z. Inst. xxviii, p. 396, 1895.

*Asterodiaspis variolosus*, Boas, Dansk. Forstzoologie, p. 395, 1896.

*Planchonia* (*Asterolecanium*) *quercicola* (Bouché) Froggatt, Dept. Ag. N.S.W. No. 175, p. 6, 1897.

*Asterodiaspis quercicola* (Bouché) Newstead, Coccidae of Brit. Is. (Ray Soc.) i, pp. 1, 14, 34, 35, 36 and 39, 1900.

*Asterolecanium variolosum*, Newst., Mon. Brit. Cocc. ii, p. 156, 1902.

Ova pale yellow to light brownish yellow according to age ; about  $190\mu$  long and  $115\mu$  broad.

Larva, just emerged, pale yellow, with legs and antennae hyaline, about  $260\mu$  long and  $145\mu$  broad. Antennae obscurely six-jointed. Caudal lobes small, tuberculate, each with one long seta, averaging about the same length as the antennae. Eyes prominent, lemon-yellow.

In the half-grown female the colour of the insect is clearly visible through the thin transparent test. It is then 0.7 mm. long and 0.55 mm. broad, caramel-brown, with a distinct white fringe and distinct transverse ridges on the dorsum (fig. 190).

At maturity the adult ♀ completely fills the test, which has become stouter and yellower but is still transparent enough to allow the greenish brown colour of the adult insect to show through plainly. At this stage the tests vary in size from 1.2 mm. long by 0.9 mm. broad and 0.26 mm. high to 1.5 mm. long by 1.3 mm. broad and 0.6 mm. high. As the eggs are matured and laid the body of the female shrinks and the posterior end of the cyst serves as an ovisac. At this stage the test is regularly domed and practically smooth, while the fringe has usually more or less worn away. The line indicating the end of the shrunken body is often very distinct, so that the front half of the test appears deep brown and the hind half pale yellow.

After clearing, staining and mounting, the adult ♀ is almost circular, with the anal extremity slightly narrowed. The anal orifice is very small and hairless, with two small spines, one on either side. The caudal lobes are obsolete, but the two long setae persist as shown in fig. 193. The figure-8 glands are small, in a single series all round the body. The antennae are rudimentary, with one long and one short spiny hair (fig. 193a).

*Habitat* : On *Quercus* sp., Cape Peninsula, Elsenburg (C. P.), Johannesburg, Irene, Pretoria and Vereeniging (Tvl.).

*Collection No.* : 18.

168. **Asterolecanium borboniae**, sp. n. (Plate viii, fig. 198).

Test of adult ♀ small, about 1 mm. long and 0.75 mm. broad, rounded in front and rather pointed behind, slightly convex, with the margin rather thickened and slightly crenulate. The extreme posterior extremity appears tubular and is upturned or recurved over the back. There is apparently no marginal or dorsal fringe. The colour is pale greenish yellow and the test is almost transparent, showing the dark body of the female at the anterior end.

When mounted the body is broad pear-shaped, about 0.9 mm. long and 0.6 mm. at greatest width, with the posterior extremity slightly produced and broadly rounded. The characters are very indistinct. The anal ring is small; the caudal setae stout, about 65 to 70 $\mu$  long, and the margin has but a single row of figure-8 glands, which are small, measuring approximately 8 $\mu$  across the pair. They are rather wide apart (about 30 $\mu$ ) and are not associated with simple glands (fig. 189). The mouth-parts, with the rostral loop, average about 185 $\mu$  long.

A ♂ mounted on the type slide from the Cape collection, measures 0.77 mm. long without the antennae and genital spike. The latter is broad and strong and measures 150 $\mu$ . The antennae are 10-jointed, measuring approximately: (1) 20, (2) 26, (3) 60, (4) 64, (5) 74, (6) 70, (7) 68, (8) 58, (9) 50, (10) 46 $\mu$ .

*Habitat*: On leaves of "gorse" (*Borbonia cordata*, Linn.), Ceres, C. P.; collected by T. F. Dreyer, November 1906.

*Collection No.*: 302.

169. **Asterolecanium pustulans** (Ckll.) (Plate vii, fig. 187; Plate viii, fig. 200).

*Asterodiaspis pustulans*, Ckll., Jl. Inst. Jamaica, i, p. 143, 1892.

*Planchonia pustulans*, Ckll., Science Gossip, xxix, p. 77, 1893.

*Asterolecanium pustulans*, Ckll., Bull. Bot. Dept. Jamaica, p. 8, 1893.

Test of adult ♀ about 2 mm. long and almost as broad, nearly circular, with the posterior extremity slightly produced. Dorsum convex, with a rather conspicuous rounded median ridge, but without transverse ridges. When young the test is flat and entirely covered with pinkish filaments, which appear to be divided on the marginal area. When a little older the dorsal filaments are missing, but there is a distinct marginal fringe of rather long pink processes. When full-grown the marginal fringe also is usually lacking. The colour of the test is greenish yellow, except when it contains the shrivelled female or eggs, which show through the semi-transparent test. On apple the insects do not make pits in the bark, nor is there a ridge around them. Marginal row of figure-8 glands single, with the addition of a single row of simple glands.

The figure-8 glands are of two sizes and are scattered over the body surface; the smaller are about equal to the marginal series in size, the others almost twice as large (fig. 200 a). Antennal tubercles prominent, with two curved spines and a minute spur (fig. 200 b). Caudal lobes moderately prominent. Caudal setae 75 $\mu$ . Anal setae 40 $\mu$ .

*Habitat*: On apple, Lourenço Marques; collected by C. B. Hardenburg. On stems of oleander, Lourenço Marques; collected by C. P. Lounsbury, October 1914.

*Collection Nos.*: 300 and B.300.



170. **Asterolecanium conspicuum**, sp. n. (Plate vii, fig. 186 ; Plate viii, fig. 196).

Test of adult ♀ about 1·5 mm. in diameter, almost circular, with a small, narrowly rounded posterior extremity. On some species of *Acacia* the insects cause distinct pits in the bark of the twigs (*A. robusta* ?), but on *A. horrida* this is apparently not the case. Occasionally the bark has been seen to cause a low rounded mound around the insect, producing an effect on the twig very similar to that caused by *Amorphococcus acaciae*.

The test is at first flat, yellowish, with short reddish hairs over and around it. Later it becomes moderately convex, smooth on top, semi-transparent and greenish yellow, with only the marginal fringe persisting. When cleared, the integument is extremely delicate and quite hyaline.

The figure-8 glands in the marginal series are comparatively small and are accompanied by small circular glands of two sizes. The caudal extremity has low rounded tubercles which are scarcely produced, each with one stout spine of moderate length and a shorter one on the inside. The anal ring has six spines almost as long as the longer ones of the lobes (fig. 196).

*Remarks.* This species is often observed to be heavily infested with a Hymenopterous parasite, and in many cases the majority of old tests show the exit holes of such insects.

*Habitat* : On *Acacia* spp. (native species only), Pretoria, Marikana, and South-West Protectorate.

*Collection Nos.* : 17 and 303.

171. **Asterolecanium bambusae**, Boisduval (Plate vii, fig. 185 ; Plate viii, fig. 195).

*Asterolecanium bambusae*, Bdv., Insectologie Agricole, 1869.

*Asterolecanium bambusae*, Sign., Ann. Soc. Ent. Fr. (4) x, p. 280, 1870.

*Asterolecanium bambusae*, Newst., Mon. Brit. Cocc. ii, p. 151, 1903.

*Asterolecanium bambusae*, Green, Cocc. of Ceylon, iv, p. 328, 1909.

Mr. Green's description, without reference to figures, is as follows :—

“ Test of adult female oval, convex above, the posterior extremity slightly produced into a blunt point where is a small terminal aperture ; smooth, glassy ; colourless, or tinged with pale green or yellow ; transparent, revealing the form of the insect and eggs beneath. Dried examples assume a more definite ochreous colour, a brown patch at anterior extremity representing the dead body of the insect. Marginal fringe pinkish, consisting of a double series of glassy filaments springing from the margin in pairs, each pair contiguous at the base and for the greater part of the length, but diverging laterally at their free extremities which meet the ends of the adjacent filaments, thus forming a series of narrow loops irregularly crossed by fine web-like threads ; the outermost series continuous, except at anal extremity, and longest ; the second (nymphal) series less than half the length of the outer, and interrupted at more or less regular intervals ; an innermost (larval) widely spaced series of crook-shaped filaments. Length (without fringe) 2 to 2·5 mm. Breadth 1·10 to 1·60 mm. Fringe, outer series 0·1 mm. ; inner series 0·04 mm.

“ Adult female insect at first more or less filling the test. After the deposition of the eggs, the abdomen becomes shrunken and the insect occupies the anterior part of the test only, the remaining cavity being packed with ova. Colour of insect dull

green, the dorsum more or less mottled with reddish brown. Dried insect uniform reddish brown. Rostrum conspicuous, pyriform, approximately central. Antennae submarginal, rudimentary, consisting of an irregular tubercle surmounted by two longish stout bristles and one short spiniform hair. Spiracles conspicuous, subglobular, at a considerable distance from margin, with scattered series of minute pores connecting them with the margin. Abdominal extremity slightly cleft; anal tubercles broad and stout, but not very prominent, each with a long seta at its apex and one or two short stout spines near the base. Anal ring stout, with six stout hairs which just project beyond the margin. Margin with a continuous series of large approximately circular thick-rimmed pores, in pairs, and a double ventro-marginal series of minute pores. There are some scattered paired pores of a slightly larger size on the dorsum, and many simple circular pores on the ventral surface of the abdomen. Length of extended insect 1.25 to 1.75 mm. Breadth 0.80 to 1.25 mm. After oviposition the insect becomes greatly shrunken and does not resume its original proportions during maceration.

"Early adult female at first pinkish, later dull green, finely maculated with reddish brown. The outermost series of the fringe is at first the shorter, but soon outgrows the nymphal fringe. Traces of the larval fringe can often be distinguished at intervals within the margin.

"In the nymphal stage the fringe is in a single series, but within the margin are remains of the divaricating filaments of the later larval stage.

"The newly hatched larva is of an oblong oval form, very pale pinkish or reddish brown. Limbs well developed. Antennae six-jointed, the sixth much the longest, with truncate apex. Margin with fourteen 8-shaped spinnerets on each side, and a median dorsal pair of similar pores immediately above the rostrum. Length 0.2 mm.

"The larva subsequently secretes a fringe of short glassy filaments which are paired and diverging on the cephalo-thoracic area, but single on the abdominal margin (although the spinnerets giving rise to these latter are of the same form as the others).

"Ova very pale pinkish or yellowish.

"Male unknown. A single example was observed, in which the dorsum was distinctly tricarinate and bore a marginal and three dorsal series of curling filaments. This may possibly be the male puparium."

The caudal extremity and part of the marginal series of figure-8 glands of the adult female are illustrated (fig. 195).

*Habitat* : On stems of large bamboo, Durban; collected on different occasions by Claude Fuller, C. P. Lounsbury and A. Kelly.

*Collection No.* : 19.

172. ***Asterolecanium euryopsis***, Fuller (Plate vii, fig. 192; Plate viii, fig. 201).

*Asterolecanium euryopsis*, Fuller, Agr. Journ. C. G. H. xiv, pp. 93-95 and 818, 1899.

As no fresh material of this species has been seen by the writer and all the numerous specimens of this collection are somewhat rubbed the following particulars are taken from Mr. Fuller's description (*l.c.*) :—

"The infested twigs have the appearance of being covered with a fine soft floss of a yellowish or white colour which is easily rubbed off and the insects exposed. The (C605)

scales within which the females live very much resemble small glass beads, or the drops of resin which the plants exude and for which they have no doubt often been mistaken. They are thin and transparent with a yellow tinge of colour, smooth and shining, and very convex, being nearly spherical. Generally the yellow colour of the scale is not noticeable as it appears either brown or dark green, according to the different stages of development of the female inside. In size they are about one-fourteenth of an inch in diameter and a little less than that in height.

" If these female scales are carefully examined with a magnifying glass it will be noticed that the floss is a production of the insect and that it is secreted through the scale at all parts, but mostly around the margin, and curls up in various directions, so that in fresh specimens the scale is quite hidden. If one of the scales is open at about this time of the year, mid-January, the eggs, small pinkish brown particles, will be found inside. Scales which contain eggs are generally parti-coloured, one half being yellow and the other brown or black. It is the yellow half which contains the eggs, and the yellow colour is due to the scale, whilst the darker portion is the dried remains of the female showing through it."

Puparium of ♂ about equal to the diameter of the female test in length, slightly less than half as wide, flat, with a slight median keel, yellow and transparent, like an empty female test. There is no definite operculum, such as is found in many species, but the extreme hind margin is split to allow the exit of the ♂.

Adult ♀, cleared and mounted, broad pear-shaped, 1.5 mm. long and 1.2 mm. broad. Body hyaline, with figure-8 glands very large and uniformly scattered except at the posterior extremity, where they are practically absent. The caudal extremity (fig. 201) is deeply excavate, with the part around the anal opening densely chitinised. The caudal setae are replaced by two stout spines, and the spines of the anal ring are comparatively very long and stout.

*Remarks.* This insect became so numerous on the harpuisbosch in certain parts of Cape Colony about the years 1898 and 1899 and appeared to have such a toxic effect upon the host-plant that it was suggested that the insect be spread as widely as possible in an endeavour to kill off the bush, which rendered large tracts of the country around Tarkastad useless. It was recorded in the *Agricultural Journal (l.c.)* that the bushes grew to a height of 8 to 10 feet and that no grass would grow under them.

*Habitat* : On harpuisbosch (*Euryops tenuissimus*, Less.).

*Collection No.* : 20.

173. ***Asterolecanium stentae***, sp. n. (Plate vii, fig. 191 ; Plate viii, fig. 199).

Test of adult ♀ about 3 mm. long, regularly oval and very convex, with the extreme posterior extremity slightly upturned. Colour greenish yellow suffused with brown, which is more intense at the margin. Dorsal surface scantily supplied with short white glassy processes.

The young female is similar in form, but is pale translucent green with a white marginal fringe and with numerous glassy filaments on the dorsum. The median line is not pronounced, but bears a large number of long glassy filaments in a longitudinal crest. The marginal fringe is about one-fourth the greatest width of the body in length (fig. 191).

♂ puparium not observed.



Cleared and mounted the adult ♀ is broad pear-shaped, hyaline, except for the mouth-parts, spiracles and anal portion. The figure-8 glands form a continuous single row around the margin, except at the sides in the vicinity of the spiracles, where a double row is present in association with single glands of two sizes. Figure-8 glands are also present in scattered form over the dorsum. A little removed from the posterior end is a transverse series of large opaque glands reminding one of the grouped glands of the DIASPINAE (fig. 199). The antennae are small tubercles with two or three small spines (fig. 199, *b*).

*Remarks.* This insect is obviously very similar to *A. thesii*, Douglas, both in general appearance and microscopic characters. It is, however, slightly larger and could be distinguished by the slight difference in colour and the slightly upturned posterior end of the test.

*Habitat:* On stems of *Caralluma caudata* (Asclepiadaceae), sent in by Miss S. Stent, July 1916. Also on *Huernia transvaalensis*, Stent, and *Stapelia* sp., in Rockery at Division of Botany, Pretoria.

*Collection No.* : 29.

#### Genus **Lecaniodiaspis**, Targ.

*Lecaniodiaspis*, Targ., Bol. Soc. Ent. Ital. i, p. 261, 1869.

*Lecaniodiaspis*, Ckll., Can. Ent. xxxi, p. 267, 1899.

*Prosopophora*, Douglas, Ent. Mon. Mag. xxviii, p. 207, 1892.

*Birchippia*, Green, Ann. Mag. Nat. Hist. (7) vi, p. 450, 1900.

The adult ♀ in this genus is entirely enclosed in a compact tough papery test, which is generally broad oval in shape and buff or yellow in colour. Its upper surface may be flat or convex, and may be ± smooth or ribbed or carinated. Occasionally there are small waxy processes on the dorsum, and the insects form shallow pits in the bark of the host-plant. In the South African species only are there waxy plates on the dorsum. There is a small, ± circular aperture at the posterior extremity of the test to allow the larvae to escape, but this is usually obscured until the eggs have hatched. The test, when first formed, fits closely to the body of the female, which gradually shrinks with oviposition until the test becomes in reality an ovisac.

The adult ♀ is sometimes apodous; in other cases there are rudimentary legs or, more rarely, they are well developed. The antennae are usually well developed, seven to nine segments being most common. The anal extremity is slightly cleft, with the outer angles generally rounded and bearing a stout seta and a few spines. The base and inner angles of the cleft are supplied with a bilobed thickening, which reminds one very strikingly of the anal plates of the LECANIINAE. The dorsal anterior margin of the cleft has a transverse chitinous band, in front of which is situated the anus. The anal ring bears 8 to 12 hairs, usually 10. The derm is plentifully supplied with 8-shaped glands, and on the dorsal surface of the abdomen there are often two longitudinal rows of cribriform plates.

#### *Key to South African Species of Lecaniodiaspis.*

##### A. Legs absent.

Test smooth, flat, not divided into plates	..	..	..	..	<i>mimosae</i> (Mask.)
Test divided into plates	..	..	..	..	<i>natalensis</i> , sp. n.

##### AA. Legs rudimentary.

Test smooth, rounded above	..	..	..	..	<i>magna</i> , sp. n.
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##### AAA. Legs well developed.

Shorter than antennae	..	..	..	..	<i>brabei</i> , sp. n.
Longer than antennae	..	..	..	..	<i>tarsalis</i> , Newst.



174. **Lecaniodiaspis mimosae** (Mask.) (Plate ix, fig. 202 ; Plate x, fig. 215).

*Prosopophora prosopidis* var. *mimosae*, Mask, N. Z. Trans. xxix, p. 316, 1897.

*Lecaniodiaspis mimosae*, Ckll., Check List Suppl. p. 392, 1899.

Test of adult ♀ about 4·5 to 5 mm. long., 3·5 mm. broad and 1·7 mm. thick, with the dorsum almost flat, the upper and lower surfaces almost parallel, with the margins rounded. When not crowded together the specimens are glued flat to the bark, button-like, but when a number are massed together they are often much distorted. The colour of the young is creamy, but later becomes suffused with brown, with a more distinct median line. The dorsal surface is flaky, without keel or transverse ridges.

♂ puparium 1·8 mm. long, 1 mm. broad, elongate oval, rather more pointed in front, flat, with a median keel and faint transverse ridges, pale brown, with a distinct semi-circular operculum.

When boiled in KOH and cleared, the derm of the adult ♀ is thin and hyaline, and the numerous gland-pores are very conspicuous. There are two dorsal rows of cribriform plates, 5 in each row. These are  $\pm$  circular, small,  $24\mu$  in diameter and minutely perforate (fig. 215, b). The antennae are long (about  $180\mu$ ), with seven or eight joints, sometimes appearing 9-segmented owing to a pseudarticulation in segment 6. The terminal segments bear several long stout processes with blunt extremities (fig. 215). Legs absent; in two cases indications of extreme rudiments of legs were found, in one case represented by leg i. and in the other by leg ii. The two pairs of spiracles are broad, and the stout tracheae generally remain after treatment with potash. The anal lobes are short; each bears one very strong spine and a few short conical ones. The stigmatic spines are long, stout, slightly curved, and clubbed (fig. 215, a).

*Habitat*: On *Acacia horrida* and other species, Fort Beaufort; collected by C. P. Lounsbury, September 1900. Port Alfred; collected by A. Kelly, March 1915. Namaqualand (Cape No. : 1254).

*Collection No.* : 22.

175. **Lecaniodiaspis natalensis**, sp. n. (Plate ix, fig. 205 ; Plate x, fig. 213).

Test of adult ♀ about 2·5 mm. long and 1·6 mm. broad at the widest part, which is about the middle, flat, somewhat elliptical with the two ends narrowed. In some cases the anterior end is broadly rounded and the posterior extremity pointed. The dorsum is flat and covered with a layer of white material, which is distinctly divided into three series of  $\pm$  rectangular plates, the appearance of which suggests an *Orthezia*. The median series is not quite so broad as the two lateral ones and consists of nine patches, the number which is apparently constant for each of the two lateral series also (fig. 205).

When placed in boiling KOH the body becomes pinkish but the liquid is not appreciably coloured.

The body of the adult ♀ is flat, about 1·8 mm. long, and 1·2 mm. broad at the widest part, which is just in front of the middle. The anterior end is often suddenly narrowed at the level of the antennae and the anterior margin rounded. The posterior portion tapers to the deeply cleft extremity. The mouth-parts are

comparatively small, with a long rostral loop. The antennae (fig. 213, *a*) are short, annular, of four or five segments. Legs entirely absent. The whole dorsal surface has numerous scattered, minute 8-shaped glands. Cribriform plates (fig. 213, *b*) small, inconspicuous, few in number. The anal cleft is as shown in fig. 213. The caudal setae are strong, and shorter than those of the anal ring ( $60\mu$ ). In addition to the two caudal setae there are five or six short spines on each caudal lobe. Anal ring with 8 long hairs ( $100\mu$ ).

*Habitat*: On stems of *Hibiscus*, Durban; collected by C. P. v. d. Merwe, July 1916.

*Collection No.*: 301.

176. ***Lecaniodiaspis magna***, sp. n. (Plate ix, figs. 206, 209; Plate x, fig. 214).

Adult females congregate on the crown of the host-plant at just about ground-level.

Test of adult ♀ about 6 mm. long, 4.5 mm. wide, and 3 mm. high, regularly broad oval, or slightly narrowed in front and with the hind margin very slightly flattened, with a faint median indentation. The dorsum is very convex, ventral surface slightly rounded. The test is entire and homogeneous in texture, smooth or very faintly roughened, without ridges, but occasionally with very faint ribbed corrugations at the sides. The colour is of a uniform biscuit tint (fig. 206).

When received, the largest specimens removed for mounting contained many eggs. The body entirely fills the test, which is thin, tough and papery. In boiling KOH the test breaks down and the liquid is stained a rich brown colour, while the ♀ takes on a rose-pink hue. When boiled for some time the body wall is clear, hyaline, and very delicate.

Adult ♀, cleared and mounted, about 3.7 mm. long, almost circular, hyaline, with the antennae and anal armature dense. Legs extremely rudimentary, represented by a small ( $50\mu$ ) conical tubercle, with a minute process at the tip and several delicate hairs which appear to represent the digitules (fig. 214, *a*). Antennae comparatively short ( $170\mu$ ), of nine segments, which are annular and slightly tapering to the apex (fig. 214). Anal ring with 10 stout hairs. Cribriform plates small, with comparatively large pores. Caudal spines short ( $27\mu$ ), two on each lobe. The anal plates are broad, each with deep wrinkles and two stout spines, and possibly two more slender, one above and one below (fig. 214, *b*). These latter are missing in the slides, but the pores indicate their presence.

*Remarks.* Two plants were submitted, the one crown bore seven large females ranging from 5 to 6 mm. in length, the other about 50 specimens identical in appearance but smaller, all the tests being about 3 mm. in length (fig. 209).

*Habitat*: On crowns of native bush with small narrow leaves; collected at Groot Drakenstein and sent in by C. W. Mally, June 1916.

*Collection No.*: 27.

177. ***Lecaniodiaspis brabei***, sp. n. (Plate x, figs. 218–218, *a*).

Test of adult ♀ about 3.2 mm. long, 2 mm. wide, and 1.5 mm. high, oval, convex, ochre-yellow, with a thin covering of greyish secretion which is easily flaked off. The dorsum is not quite smooth, but has faint rounded rib-marks and occasionally a faint

median ridge. With the roughened secretion removed the colour and general appearance of this species is very like the figure Green gives of his *L. azadirachtae*.

♂ puparium of the usual type, pale buff-coloured, not yellow as is the ♀ test.

Larva yellow, 0.5 mm. long, and 0.24 mm. wide. Antennae and legs well developed. Antennae 5-segmented; basal segment cylindrical, hardly as wide as ii. The posterior extremity of the body is narrowed and deeply and roundly indented, so that there appear to be two large caudal lobes. The inner margins of these have chitinous plates similar to those of the adult; the transverse chitinous bar in front of these is not very conspicuous. The caudal lobes each bear one very long seta, about 0.2 mm. in length and one or two short spines.

Second stage ♀ about 1.2 mm. long. In this stage the body has become more rounded, especially at the posterior extremity. The caudal lobes are comparatively shorter and their extremities are curved together, and the long caudal setae of the larva are replaced by two stout spines about  $35\mu$  in length. The antennae and legs are situated further from the margin and appear proportionately smaller. The antennae are 6-jointed.

Adult ♀, cleared and mounted, about 3 mm. long, almost circular, with the derm colourless, hyaline. The legs are well developed, but small, shorter than the antennae ( $180\mu$  :  $250\mu$ ). The three pairs of legs are about equally developed (fig. 218, c). The antennae are normally 8-jointed, but occasionally appear 9-jointed through the pseudo-articulation of the 5th segment (fig. 218). There are scattered stout spines, about  $27\mu$  long, on thick bases, at intervals around the margin (fig. 218, b). The stigmatic spines are usually unequal, one long and one short, curved, slightly clubbed (fig. 218, a). Figure-8 glands small, uniformly scattered over the surface.

*Remarks.* This species is similar in many respects to *Lecaniodiaspis africana*, Newst., but is readily distinguished by the smaller size and the fact that the antennal segments iii, iv, v, and vi, are longer than wide and the tarsus is considerably longer than the tibia (fig. 218, c).

*Habitat:* On wild almond (*Brabeium stellatifolium*, Linn.); collected by C. P. Lounsbury, Newlands, 1896 (Cape No.: 1274); also collected by C. W. Mally, December 1915.

*Collection No.:* 298.

# 178. *Lecaniodiaspis tarsalis*, Newst. (Plate ix, fig. 203; Plate x, fig. 217).

*Lecanium tarsalis*, Newst., Bull. Ent. Res. viii, p. 16, 1917.

Test of young ♀, about 1.5 mm. long, flat, with a distinct median keel, purplish grey in colour.

Test of adult ♀ buff-brown, about 3 mm. long, 2 mm. broad and 1 mm. high, with the dorsum roughened by a series of low tubercular projections. There is a distinct median series and a sub-dorsal row on each side, the marginal areas being irregularly roughened.

♂ puparium creamy white, about 1.3 mm. long, and 0.9 mm. wide; similar in form to the ♀ test but more flat and much lighter in colour.

Adult ♀, mounted, about 1.6 mm. long and 1.1 mm. broad, regularly oval, with a complete regular marginal row of stout spines  $30\mu$  in length, about 15 on each side

(fig. 217, *b*). Legs and antennae present. All three pairs of legs about equally developed, all longer than the antennae. Antennae 9-jointed (fig. 217). Caudal setae stout, about  $80\mu$  in length. Cribriform plates small ( $12\mu$  diameter), yellow (fig. 217, *a*). On the venter, a little anterior to the position of the anal ring, are two long straight slender setae, about  $115\mu$  in length, pointing backward.

*Habitat*: On native tree (*Dombeya rotundifolia*), Pretoria; collected by the writer, September 1914. On *Hibiscus* in a nursery, Pretoria; collected by A. Kelly, June 1916.

*Collection No.* : 23.

#### Genus **Cerococcus**, Comst.

Adult ♀ enclosed in a dense waxy test without a marginal fringe as in *Asterolecanium*, and generally without waxy processes. The test is usually dense, opaque, not semi-transparent, and simulates the test of a *Tachardia* more than that of an *Asterolecanium*. The posterior end of the test is sometimes slightly produced and upturned, with the anal aperture at the extremity.

Adult ♀ with the caudal extremity produced into a rounded protuberance which bears the anal armature. There are two stout lobes, each with a long seta and several spines; the space between them is  $\pm$  chitinised, with a prominent rounded tongue-shaped plate. Antennae and legs rudimentary. Derm with conspicuous 8-shaped glands. Stigmatic spines absent.

♂ puparium elongate, tubular, with a large oval or circular operculum above the posterior extremity.

#### *Key to South African Species of Cerococcus.*

- A. Test smooth,  $\pm$  globular, brown .. .. . *ovoides* (Ckll.).
- AA. Test rough, ornate, brick-red .. .. . *ornatus*, Green.
- AAA. Test yellowish or brownish.

Marginal 8-shaped glands much larger than those on dorsum *passerinae*, sp. n.

Marginal 8-shaped glands little if any larger .. . *royenae*, sp. n.

#### 179. **Cerococcus ovoides** (Ckll.) (Plate x, fig. 219).

*Pollinia ovoides*, Ckll., The Entom. xxxiv, p. 225, 1901.

Professor Cockerell's description is as follows:—

“♀ scale a rounded conical object much like a Lepidopterous egg, about  $1\frac{1}{2}$  millim. diam., roughened radiately, pale brown with four longitudinal stripes of white secretion converging to the top of the scale, which is usually reddish.

“♂ scale elongated, about  $\frac{2}{3}$  millim. long, roughened, yellowish or pink, with an oblique terminal cap.

“♀ scales, soaked in liquor potassae, give a deep orange-brown colour, and the insects themselves turn deep crimson; ♀ adult globose; skin with many simple round glands and tubular glands, and some figure-of-8 glands; anal ring with numerous hairs; caudal lobes prominent, conical, about  $45\mu$  long, with a few small spines, and ending in stout bristles about  $90\mu$  long; mouth-parts well developed, but small; labium short and broad, dimerous, the last joint with bristles on its margin; antennae



represented by small rounded tubercles about  $15\mu$  long, with a little terminal prominence which appears to represent a second joint, and about six stout bristles about  $18\mu$  long; spiracles small but distinct; legs wanting.

"Embryonic larva with a row of figure-of-8 glands down each side, and dorsal and subdorsal rows of small round glands, the latter failing caudad, the last five glands of the dorsal rows being absent in the subdorsal; labium very short and broad, cup-shaped; form of insect elongate-pyriform; antennae thick, 6-jointed, last joint not very greatly longer than the one before, and notched as in *P. pollini*."

The antennae and caudal extremity are figured (Plate x, figs. 219 and 219, a).

*Habitat*: On stems of undetermined native tree, Back Beach, Durban; collected by C. Fuller. On fig, Pietermaritzburg; collected by A. Kelly, 1911.

*Collection No.*: 26.

# 180. *Cerococcus ornatus*, Green.

*Cerococcus ornatus*, Green, Cocc. Ceylon, iv, p. 306, 1909.

Mr. Green's description, omitting figure references, is as follows:—

"Test of adult female irregularly oval, the posterior extremity (in fully matured examples) produced into a short upturned tube. In earlier examples this caudal extension is in the form of a trough, partially closed above by stout curling filaments. Dorsum strongly convex, the sides sloping inwards to the comparatively narrow ventral area, which is thin and easily ruptured. Dorsum with three prominent transverse waxy ridges produced, at the middle and two sides, into stout pointed processes; the lateral processes longest, tapering to fine points, and projecting (in fresh examples) considerably beyond the margin, which is itself thickened and tubercular. Posterior margin with two or more tapering processes directed backwards. There are several pairs of short white curved filaments on the median line, behind the third transverse ridge. In older examples the waxy processes are gradually reduced until they practically disappear, and old worn tests are more or less globular in form. Colour of early test purplish brown; the ridges, processes, and thickened margins bright coral-red or crimson. Older examples become at first uniform pale red, and finally dull reddish brown. There are two white waxy ridges on each of the sloping sides, extending from the first and third lateral processes, respectively, to the stigmatic openings. Length 2 to 2.5 mm. Breadth (exclusive of processes) 1.12 to 1.50 mm.

"Male puparium oblong, narrow, rounded at the extremities. An inconspicuous median and two prominent transverse ridges, the latter terminating laterally in pointed processes. A smaller pointed process, on each side, close to anterior extremity. Posterior third occupied by a large circular operculum with raised margins. Colour pale red to crimson. Length, 1 mm. Breadth, 0.45 mm.

"Adult female insect of a delicate greyish tint, in life. Broadly oval: the terminal segments abruptly narrowed. Abdomen terminating in two prominent irregularly conical lobes, with a bluntly conical median plate between them; each lobe with a triangular chitinous plate on its inner side and a longish stout seta at its apex. Ventral lip of anal aperture with four or more long stout spines. Anal ring with eight hairs. Rudimentary antenna with from eight to twelve stout hairs on its apex.

Limbs entirely wanting. Dorsum with numerous large and conspicuous paired glands, disposed principally in three broad transverse bands across the middle of the body, leaving the anterior and posterior areas comparatively free. The first and third bands divide near the margins, where they enclose a series of small circular glands. There is a straggling group of the large paired glands within the anterior margin; a short marginal series on each side of the abdomen, just before the constriction; and another short series, on each side, close to the anal lobes. Amongst the larger paired glands, and scattered over other parts of the dorsum, are many of a much smaller size. Cribriform plates small, each with a broad densely chitinous border and areolate centre; in two groups of four, immediately anterior to the narrowed part of the abdomen. Venter with small circular glands in loose transverse series across the abdominal segments, and some scattered paired glands of the smaller size. Length, 2 mm.

"Adult male uniform dark brown. Wings hyaline; nervures colourless. Genital sheath very broad at base; sharply pointed at extremity. Although the single example examined showed no waxy caudal filaments, there is a distinct glandular pit on each side, giving rise to fine paired setae such as usually support caudal filaments. Length, 1 mm. Expanse of wings, 1.75 mm."

*Habitat*: On stems of *Aberia caffra* and *Calodendron capense*, Thunb.; collected at Pietermaritzburg by A. Kelly, April 1917.

*Collection No.*: 95.

181. **Cerococcus passerinae**, sp. n. (Plate x, fig. 216).

Test of adult ♀ about 2.4 mm. long, elongate, convex, with the posterior end slightly produced, thin, brittle, dull straw-yellow. The dorsum is convex, with a wide shallow groove from about the middle to the caudal end. The remainder of the test is uniformly arched, but in a few specimens there appears to be a submarginal series of low tubercles.

Puparium of ♂ usual, elongate, paler in colour than the ♀ test.

Cleared and mounted the adult ♀ is broad pear-shaped, with the prominent anal portion produced. The integument is thin and hyaline, with 8-shaped glands numerous but scattered. Those of the marginal series are large, and mostly in a single row, but at the sides the series becomes double or treble for a short distance. The 8-shaped glands scattered over the dorsum are smaller, being only about half the diameter of those in the marginal series. The rudimentary antennae consist of small conical protuberances each with about 6 spines (fig. 216, a). The caudal lobes are prominent, with their inner faces chitinated and the spines strongly developed (fig. 216).

*Habitat*: On native shrub (*Passerina ericoides*, L.; Thymelaeaceae); collected by C. P. v. d. Merwe at Montague, C. P., October 1914.

*Collection No.*: 24.

182. **Cerococcus royenae**, sp. n. (Plate ix, fig. 210).

Test of adult ♀ varying in size to 3 mm. long and almost as broad and high, very roundly convex, with a short caudal prominence around the aperture. The test is comparatively thick and brittle, dull orange-yellow to orange-brown in colour, without fringe or processes of any kind.

The ♂ puparia are elongate, tubular, open behind, straw-coloured, with a brownish secretion, which often appears in  $\pm$  rectangular patches on each side of the median line (fig. 210).

The mounted ♀ is almost circular, with the caudal extremity slightly produced. The integument is clear and has a marginal series of 8-shaped glands of medium size. Other similar glands are scattered over the dorsum and these are of about the same size as those of the marginal series, not much smaller as in *C. passerinae*. The antennae are small conical protuberances with several curved spines, and are longer and narrower than in *C. passerinae*. The caudal lobes are moderately long, but are not thickened on their inner edges, and a short distance in front of the anal ring are two chitinised discs.

*Habitat*: On stems of blauwbosch (*Royena pallens*, Thunb.; Ebenaceae), Fauresmith, O. F. S.; collected by J. C. Faure, March 1915.

*Collection No.*: 96.

#### Subfamily TACHARDIINAE.

"Insects enclosed in a resinous cell with three orifices. Adult females apodous, with the terminal segments produced into a tail-like organ bearing, at the extremity, the anal orifice, which is surrounded by a broken setiferous ring" (Green).

#### Genus *Tachardia*, R. Blanchard.

Professor Cockerell ("The Entomologist," xxxiv, p. 249, 1901), before describing *Tachardia albida* from Natal, gives the following synopsis of this genus:—

"*Tachardia*, Blanchard (Lac Insects).

This genus contains some very diverse elements, which will no doubt eventually be treated as genera. We may for the present recognise three subgenera:—

- (1) *Tachardia* proper. Type, *T. lacca*, the East Indian commercial lac. Female very elongated, vasiform; the individuals enclosed in masses of lac surrounding the twigs, never separate. I know of only one species of this group.
- (2) *Tachardiella*, subg. nov. Type, *T. cornuta*, Kkll. Female more or less globular; individuals often separate. This includes the species of America and Australia.
- (3) *Tachardina*, subg. nov. Type, *T. albida*, with the characters given below."

It will be noticed from the description of *T. albida* given later that the main points of difference between this and the other species mentioned by Professor Cockerell are (a) the tests are collected in large masses; (b) the caudal process is peculiar; (c) the spine is absent. Of these characters none is peculiar to the African species, and *T. albida* is the only species I know of in which the spine is absent. I therefore follow Newstead in disregarding the subgenera for the present and including the six South African insects in the genus *Tachardia*.

I might mention that the insects in this sub-family are by far the most difficult to make satisfactory microscopic slides of, as nearly all the old dry specimens seem to be eaten out, and after dissolving the lac test there usually remain but a few fragments which are quite useless for determination. Fresh material is therefore most desirable in this group.

*Key to South African Species of Tachardia.*

## A. Antennae present.

- a. Test crimson or deep red, with pale radiating lines . . . *actinella*, Ckll. & King.  
 aa. Test deep shellac-brown,  
 b. Rudimentary legs represented by small conical spines . . . *minor*, sp. n.  
 bb. Legs entirely absent . . . . . *karroo*, sp. n.

## AA. Antennae absent.

## B. Spine present.

- a. Test deep purplish brown, with radiating ridges . . . . . *decorella* (Mask.)  
 aa. Test yellowish brown . . . . . *affluens*, sp. n.

## BB. Spine absent.

- a. Test whitish or pale yellow . . . . . *albida*, Ckll.

183. **Tachardia actinella**, Ckll. & King (Plate ix, fig. 208; Plate xi, fig. 221).

*Tachardia actinella*, Ckll. & King, The Entom. xxxiv, p. 342, 1901.

The original description is as follows:—

“ ♀. Scale about 3 mm. long, 3 broad, and scarcely 2 high, rounded and depressed, dark crimson, with about sixteen strong, but obtuse, radiating yellowish white ridges; centre of scale formed as in *T. decorella*. The scales are mostly separate, but sometimes two or more coalesce.

“ ♀. Dark red,  $2\frac{1}{2}$  mm. long,  $1\frac{1}{2}$  broad; bright pink when boiled in caustic potash; this colour is due to the internal juices, the skin being perfectly colourless. Antennae stout, cylindrical, pale, about  $140\mu$  long, 52 broad at base, 36 in middle, 28 at end, obscurely four-jointed. Lac glands with over 60 orifices. Mouth-parts about  $141\mu$  broad. Spine well-developed,  $120\mu$  long, rapidly enlarging  $35\mu$  from tip to a very broad ( $95\mu$ ) base. Anal ring with 10 long bristles; chitinous anal plate roughly semicircular, posteriorly with a deep linear incision  $60\mu$  long; on each side of the anal plate is an elongated process terminating in two sharp spines, the structure being apparently the result of a fold in the plate. Anteriorly, the anal plate is tuberculated.

“ ♂. Scale cylindrical, elongated, of the usual form; dark red.”

A large collection of ♂ material was received from Grahamstown in March 1915 when the insects were just emerging. The following particulars are therefore added from notes made at the time:

♂ test deep madder-red, glassy, about 1 mm. long and 0.5 mm. broad; flat, upper surface slightly arched, with a median flatly-rounded keel with transverse striae. The anterior end is rounder but narrower than the posterior extremity, which is somewhat elevated, so that the opening from which the ♂ emerges appears dorsal. Prior to emergence this orifice is closed by a glassy cap. When the insect is ready to emerge the cap is raised from behind and the two white caudal filaments protrude.

Body of ♂ adult (freshly mounted) 1.2 mm. long, and 0.33 mm. broad across the thorax. Genital spike 0.24 mm. long. Wing 0.95 mm. long. The body and scutellum are of a beautiful madder-red colour; the eyes are black; the legs and antennae pale, almost colourless; and the wings are clear but iridescent.



Caudal filaments (2) long, from  $1\frac{1}{4}$  to  $1\frac{1}{2}$  times the length of the body. These are dense white, slender, and in life widely divergent. The antennae are 10-jointed, the joints, when freshly mounted, measuring approximately:—(1) 30, (2) 58, (3) 100, (4) 92, (5) 85, (6) 68, (7) 58, (8) 68, (9) 50, (10)  $65\mu$ .

*Habitat* : On orange, Qumba, C. P. On pomegranate, Ladysmith, Natal. Also on native trees at East London and Grahamstown, C. P., Natal and Transvaal.

*Collection Nos.* : 71, 75, 325.

184. **Tachardia minor**, sp. n. (Plate xii, fig. 227).

♀ test 1.5 to 2 mm. in diameter, rich castaneous brown, with the larval cast conspicuous. Viewed from above the test is broad heart-shaped; edges of caudal orifice slightly elevated; spiracular openings obsolete. In the material examined the ♀ tests always appeared singly on the twigs, never massed as in *T. actinella*.

♂ puparium about 1 mm. long, varying in colour from pale yellowish brown to deep castaneous; dorsal area strongly ridged.

When cleared and mounted the adult ♀ is almost circular and very transparent; the mouth-parts are comparatively large, averaging about  $170\mu$  long by  $82\mu$  at their greatest width. On each side, extending backward from the middle of the mouth-parts, is a series of three small conical spines, which appear as though they might indicate the extreme rudiments of legs. The antennae average  $60\mu$  in length and are obscurely 3 or 4-jointed. Lac plates varying from  $57$  to  $68\mu$  in length; about  $48\mu$  broad; with few glands, the number varying from 14 to 28 in specimens examined. Spine about  $68\mu$  long and  $54\mu$  across the base, distinctly funnel-shaped, narrowing at about half its length. Chitinous anal plate almost semi-circular, with the basal portion rugose and its apex four lobed. Anterior spiracle with 16 simple glands.

*Habitat* : On rhenosterbosch (*Elytropappus rhinocerotis*, Less.); collected by C. P. v. d. Merwe, Montague, C. P., November 1914.

*Collection No.* : 25.

185. **Tachardia karroo**, sp. n. (Plate xii, fig. 230).

♀ test 2.5 to 3.5 mm. in diameter, sometimes sing'e, but usually massed together on the thicker stems of the plant. Somewhat similar to *T. minor* but more spherical, larger and paler in colour. In a number of cases the test is semitransparent, deep amber-yellow, with three distinct pale lines radiating from the median dorsal ridge to the margins in the form of a broad Y.

♂ puparium comparatively short, deep chestnut-brown.

When cleared and mounted the following characters may be determined:—The antennae are obscurely 3-jointed, about  $105\mu$  long and  $27\mu$  wide at the base. The apical joint has at its tip 3 or 4 short spines. The anterior spiracle has a few (2 or 3) simple glands. Lac plates about  $120\mu$  long by  $110\mu$  broad, with 62 to 84 gland openings. Spine about  $90\mu$  long and  $78\mu$  across the base; deep funnel-shaped, narrowing about one-third to one-fourth its length from the tip. Anal plate broader than long; basal portion coarsely wrinkled, apical part with 4 small pointed lobes.

*Habitat* : On rhenosterbosch (*Elytropappus rhinocerotis*, Less.) in association with *T. minor*; collected by C. P. v. d. Merwe, Montague, C. P., November 1914.

*Collection No.* : 324.

186. **Tachardia decorella** (Mask.) (Plate ix, fig. 212 ; Plate xi, fig. 222).

*Carteria decorella*, Mask., N. Z. Trans. xxv, p. 247, 1892.

*Tachardia decorella*, Newst., Bull. Ent. Res. viii, p. 127, 1917.

The ♀ tests generally coalesce so as to form a mass completely surrounding the thin twigs of the host-plant, often for a length of 30 to 40 mm. The individual tests, at maturity, are almost globular, but flattened above, 3 to 4 mm. in diameter, deep purplish brown, or almost black, with dull grey speckles arranged in radiating ridges. The intermediate spaces are somewhat glossy. The lac is very hard and brittle.

The larval tests are deep red. Those of the young females are flat and button-like, brown, with the reddish larval cast superimposed and with the grey ridges more pronounced than in the adult.

When mounted the body is broad ovate and transparent. The anal plate is densely chitinised, about  $190\mu$  broad and  $170\mu$  long, with its basal portion embossed with very small "grease spot" design. The mouth-parts are about  $185\mu$  long and  $126\mu$  across the middle. The lac-gland plates are approximately  $170\mu$  long and have numerous gland openings, all the specimens examined having over 100. The spine is shallow funnel-shaped, about  $120\mu$  long and  $112\mu$  across the base, becoming abruptly narrowed at about two-thirds its length from the apex. Near the margins of the segments are more or less circular groups of simple glands.

This insect differs in some small details, such as the colour of the test, from Maskell's description of *T. decorella*, but the marginal gland groups and other characters are so close that, for the present at least, I ascribe his name to the species.

*Habitat*: On *Acacia karroo*, Linn., Crocodile River, Transvaal. On *Acacia melanoxylon*, Zoological Gardens, Pretoria.

*Collection No.* : 323, 326.

187. **Tachardia affluens**, sp. n. (Plate xi, fig. 224).

Test of adult ♀♀ usually found singly on the stems of host-plants ; occasionally in groups of two or three, never in large groups.

Test ± globular, almost as deep as wide, sometimes slightly tapering to the top, about 3 mm. in diameter, yellowish to dull shellac-brown with a reddish spot in the centre. The test is generally smooth, but may show indications of faint ridges to the margins, which are prominent in young specimens.

♂ puparium exceptionally long and narrow, pale yellowish brown, with reddish larval cast ; posterior aperture closed by a rough buff flap.

When mounted the characters are indistinct, but the following measurements have been supplied from the examination of a range of specimens :—Mouth-parts about  $170\mu$  long and  $100\mu$  wide. Spine about  $100\mu$  long and  $85\mu$  at base, rapidly tapering so that the apical half is almost parallel-sided. Lac plates small, about  $85\mu$  long and  $75\mu$  broad, with approximately 40 gland openings, all in a compact group. The anal plate is more straight-sided than usual and ends in four almost equal lobes. Its base is slightly wrinkled and has scattered transparent spots, giving it the grease-spot appearance something like the design on the dorsum of a *Pseudaonidia*.

*Remarks.* This species resembles *T. longisetosa*, Newstead, but is easily distinguished by the fact that the hairs of the anal ring are of normal length, and the glands of the lac-plates are fewer in number and not scattered.

*Habitat:* On *Euclea* sp. and other native plants; very common around Pretoria and apparently widespread throughout the Union.

*Collection No.:* 76.

188. ***Tachardia albida***, Ckll. (Plate ix, fig. 211).

*Tachardia albida*, Ckll., The Entom. xxxiv, p. 249, 1901.

Professor Cockerell's description is as follows :—

“ Forming smooth yellowish-white masses on the twigs; the extremely dense and hard lac of the several individuals running together; masses up to 10 mm. diam., and 30 in length. The individuals are marked externally by orange patches, each presenting a small corrugated or segmented ridge, and an aperture. Cavities for females globular to subpyriform. Male scales of the usual elongated form, red, with a very short dorsal segmented ridge, about one-third of total lengths of scale.

“ ♀. After boiling in liquor potassae globular, giving a very fine crimson colour. Skin after boiling transparent, truncate and caudal processes remaining ferruginous. Mounted female on slide about 5 mm. diameter. Truncate processes (or ‘lac tubes’) very short, orifices very small and numerous. Spine apparently absent. Caudal process peculiar; transversely oblong or subreniform, with a deep posterior notch, on each side of which are two lobules; lateral hind margins bearing a sharp spine; surface finely reticulated; anal ring hidden, only the ends of the numerous bristles projecting. Spiracles large and well-developed. Mouth-parts well-developed, but small, about  $135\mu$  broad; “lobes oraux” (as figured by Targioni-Tozzetti in *T. lacca*) very large.

“ Larva in female fusiform, narrow, tapering posteriorly, about  $560\mu$  long and 240 broad; caudal bristles very long.”

*Habitat:* On *Acacia karroo*, Linn., Verulam, Natal (Fuller No. 5), and Pienaars River, Transvaal; collected by the writer, January 1917.

*Collection No.:* 72.

Subfamily ?

Genus ***Halimococcus***, Ckll.

*Halimococcus*, Ckll., The Entom. xxxv, p. 15, 1902.

Only one species has yet been described *i.e.*, *H. lampas*, Ckll. Professor Cockerell's original descriptions of the genus and type species are as follows :—

“ A Dactylopiine Coccid enclosed in a horny sac shaped like that of *Solenococcus*, without legs or antennae in the adult. Larva with no rows of dorsal spines, no hairs on anal ring, and no caudal tubercles, but four long caudal bristles as in *Phoenicococcus*. Closely related to *Phoenicococcus* (which lives in Algeria), but distinguished by the form of the sac, which exactly imitates that of *Solenococcus*.”

189. **Halimococcus lampas**, Ckll. (Plate ix, fig. 204 ; Plate xii, fig. 225).

*Halimococcus lampas*, Ckll., The Entom. xxxv, p. 15, 1902.

" ♀. Enclosed in a dark brown horny sac (which is not dissolved by liquor potassae), which is shaped like a *Terebratulula* shell, i.e., oval, with the end raised and terminating in an orifice. Length of sac  $510\mu$ , breadth  $300\mu$ , breadth of orifice about  $66\mu$ . The orifice is closed by a reticulated plate, except basally, where there is a semilunar opening. In immature examples the sac is prominently segmented on the ventral side.

" ♂. Scale small, cylindrical, horny, ferruginous, of the same texture as that of the female, but usually somewhat paler. Length  $350\mu$ , breadth 140. The end comes off, leaving a round opening, as in Muscid pupae.

" ♀. A mere bag, with well-developed mouth and spiracles.

" Larva. Rather narrow ; legs and antennae present. No caudal tubercles, but two pairs of long caudal bristles ; two small bristles close to these. Antennae about  $45\mu$  long, six-jointed, last joint much the longest. No dorsal spines. Last antennal joint with two long bristles. Femur remarkably stout, about  $15\mu$  broad ; length of femur + trochanter about  $30\mu$ .

" Older specimens have actually shorter ( $36\mu$ ) antennae, with joint 6 longer than 4 + 5 ; 5 longer than 3, 3 longer than 4, 1 large.

" A few white curled waxen threads protrude from beneath the sacs of the females."

*Habitat* : On leaves of palm (*Hyphaene crinita*), Durban, Natal ; collected by C. Fuller about 1901.

*Collection No.* : 42.

#### Genus **Baccacoccus**, nov.

Allied to the LECANIINAE. Body of adult ♀, at maturity, naked, without test or waxy covering, almost globular, appearing like a berry on the twigs of the host-plant. In the type species the colour is yellow to orange, often with a faint metallic bronzy sheen, the whole insect simulating a *Margarodes* cyst. Antennae well-developed, 7 jointed. Legs well-developed, long, upper and lower digitules present, clubbed. Anal ring large, with numerous (16 ?) hairs. Stigmatic clefts, two on each side, with 4 or 5 broad conical protuberances supplied with glands.

Type, *B. elytrapappi*, sp. n.

190. **Baccacoccus elytrapappi**, sp.n. (Plate ix, fig. 207 ; Plate xii, fig. 226).

Adult female almost globular, to 3 mm. in diameter, yellow to brownish, glossy, like a *Margarodes* cyst, with the small brown anal plates occupying the position of the caudal pore of an *Asterolecanium* test. In the middle of the dorsum there is a prominence, like a minute keel, occasionally with two rounded prominences in close proximity but a little posterior to it. There is no fringe in the material at hand, but four short white bands, two on either side from the stigmatic clefts at the point where the insect is attached to the thin twig or leaf of the host-plant.

When cleared and mounted the derm is almost hyaline, appearing yellowish, with the antennae and legs of about the same density. The integument is without gland-pores and hairs except immediately around the anal plates (fig. 226, d). The



legs are long and slender, with long slender digitules, which bear spherical knobs. The lower digitules of the claw are stouter and shorter. The antennae are 7-segmented with joints 3 and 4 long, and almost equal. The stigmatic clefts are broad and shallow with 4 or 5 low conical glandular protuberances (fig. 226, c). The anal ring has numerous (10 to 12) long hairs and is closed above by two plates as illustrated in the figure.

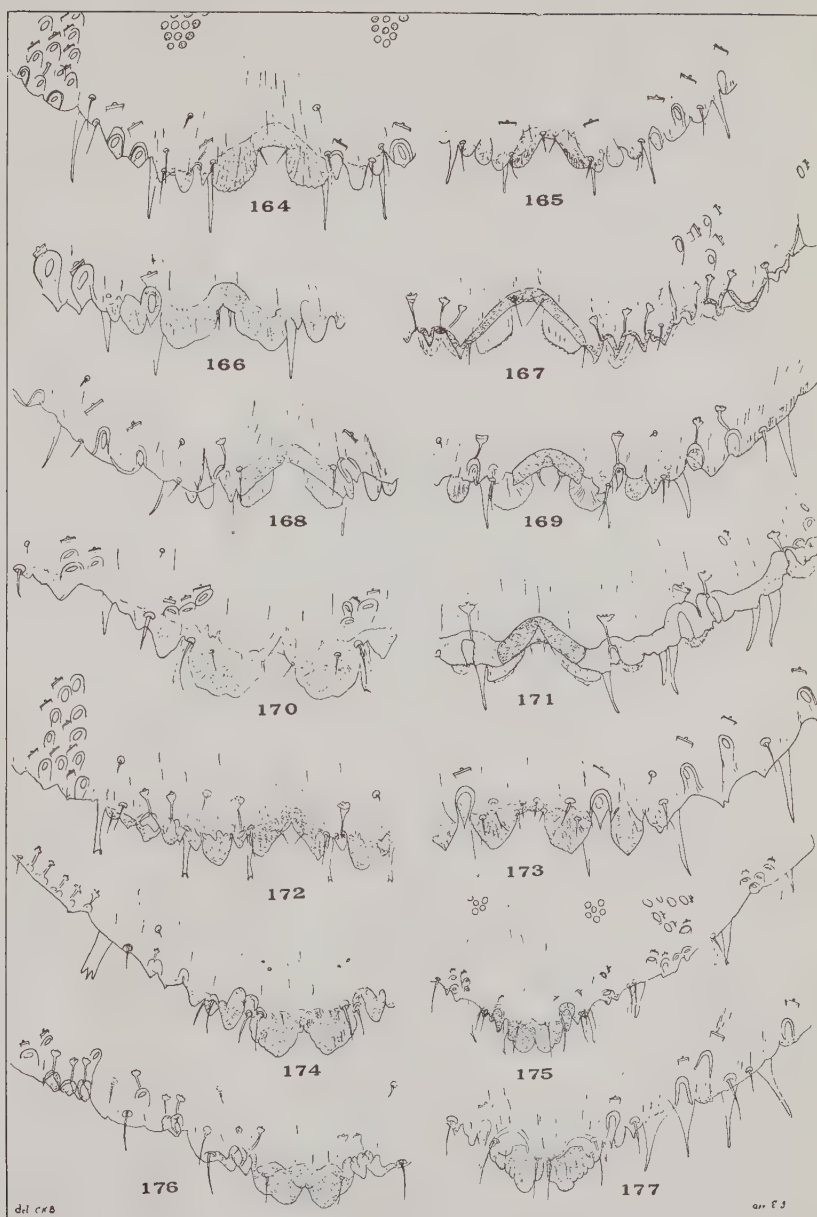
*Habitat* : On thin twigs of rhenosterbosch (*Elytropappus rhinocerotis*, Less.), French Hoek, C. P. ; collected by C. P. Lounsbury, 1904.

*Collection No.* : 297.



## EXPLANATION OF PLATE V.

- Fig. 164. *Chionaspis* (*Poliaspis*) *carissae*, Ckll.  
 165. „ (*Phenacaspis*) *natalensis*, Ckll.  
 166. „ *leucadendri*, sp. n.  
 167. „ (*Dinaspis*) *diosmae*, sp. n.  
 168. „ (*Phenacaspis*) *lounsburyi* var. *ekebergiae*,  
 var. n.  
 169. *Chionaspis* (*Phenacaspis*) *lounsburyi*, Cooley.  
 170. „ (*Dinaspis*) *distincta*, Leon.  
 171. „ *leucadendri*, sp. n. (see fig. 166).  
 172. „ (*Dinaspis*) *lounsburyi*, Leon.  
 173. „ sp. on shrub (name of host-plant and  
 locality not known).  
 174. *Chionaspis caffra*, sp. n.  
 175. „ *chionaspitiformis* (Newst).  
 176. „ *scutiae*, sp. n.  
 177. „ *ambiguus*, sp. n.



South African Coccidæ.







EXPLANATION OF PLATE VI.

Fig. 178. *Chionaspis simplex*, Green, var.

179. „ (*Dinaspis*) *imbricata*, sp. n.

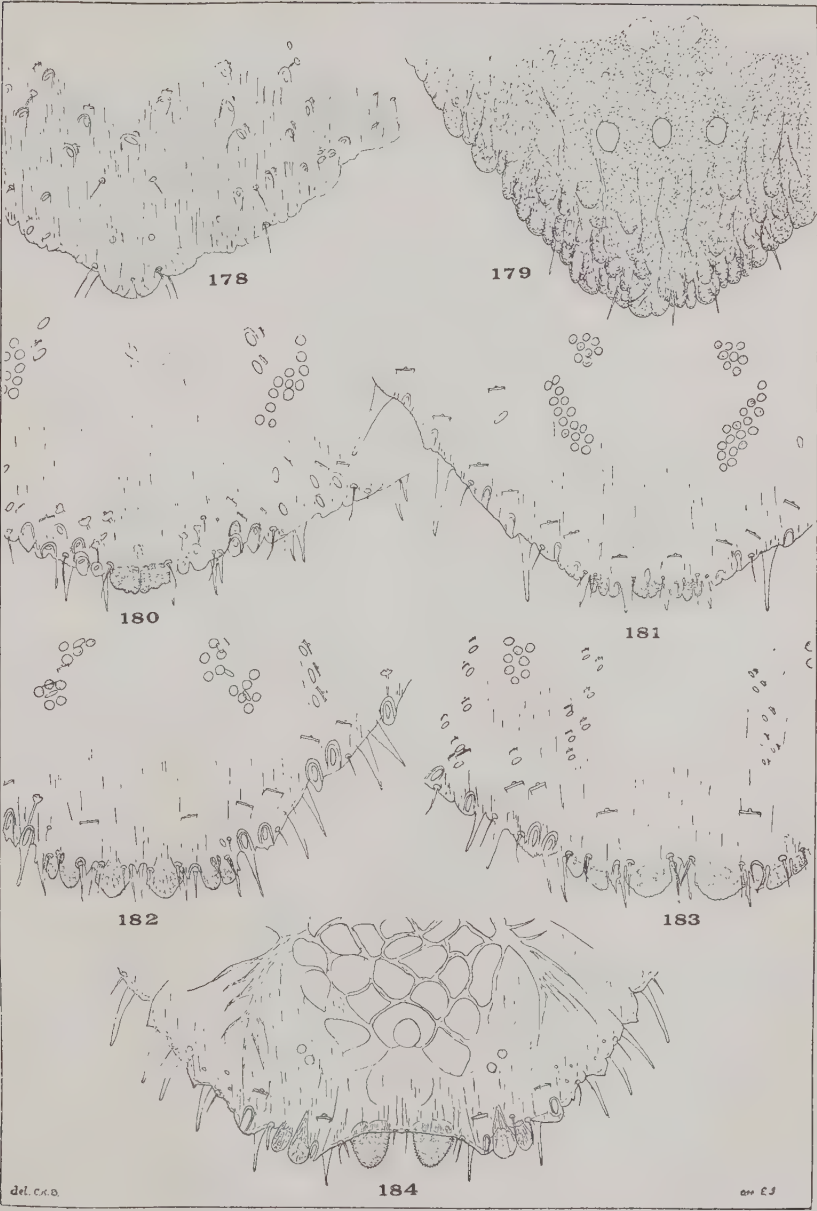
180. „ (*Pinnaspis*) *cyanogena* (Ckll.).

181. „ (*Pinnaspis*) *aspidistrae*, Sign.

182. *Lepidosaphes gloveri* (Packard).

183. „ *pinnaeformis* (Bouché).

184. *Ischnaspis longirostris*, Sign.



South African Coccidæ.

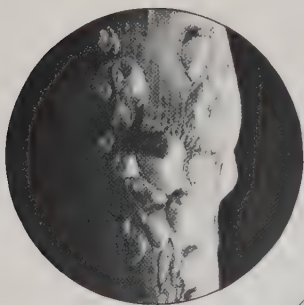




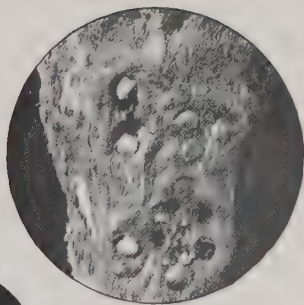


## EXPLANATION OF PLATE VII.

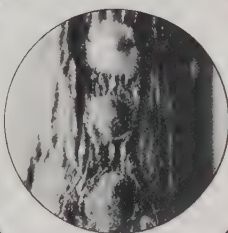
- Fig. 185. *Asterolecanium bambusae*, Bdv.  
186.       ,,       *conspicuum*, sp. n.  
187.       ,,       *pustulans*, Ckl.  
188.       ,,       *brevispinum*, sp. n.  
189.       ,,       *pustulans* var. *brachylenae*, nov.  
190.       ,,       *variolosum*, Ratz.  
191.       ,,       *stentae*, sp. n.  
192.       ,,       *euryopsis*, Fuller.



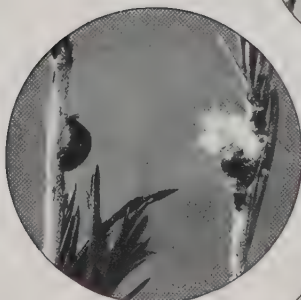
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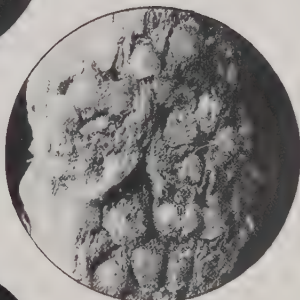
186.



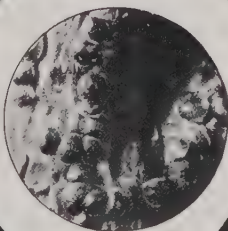
187.



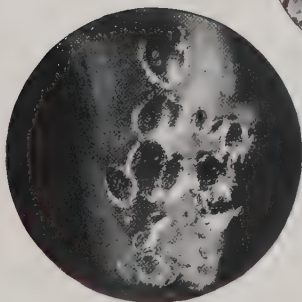
188.



189.



190.



191.



192.

C.K.B

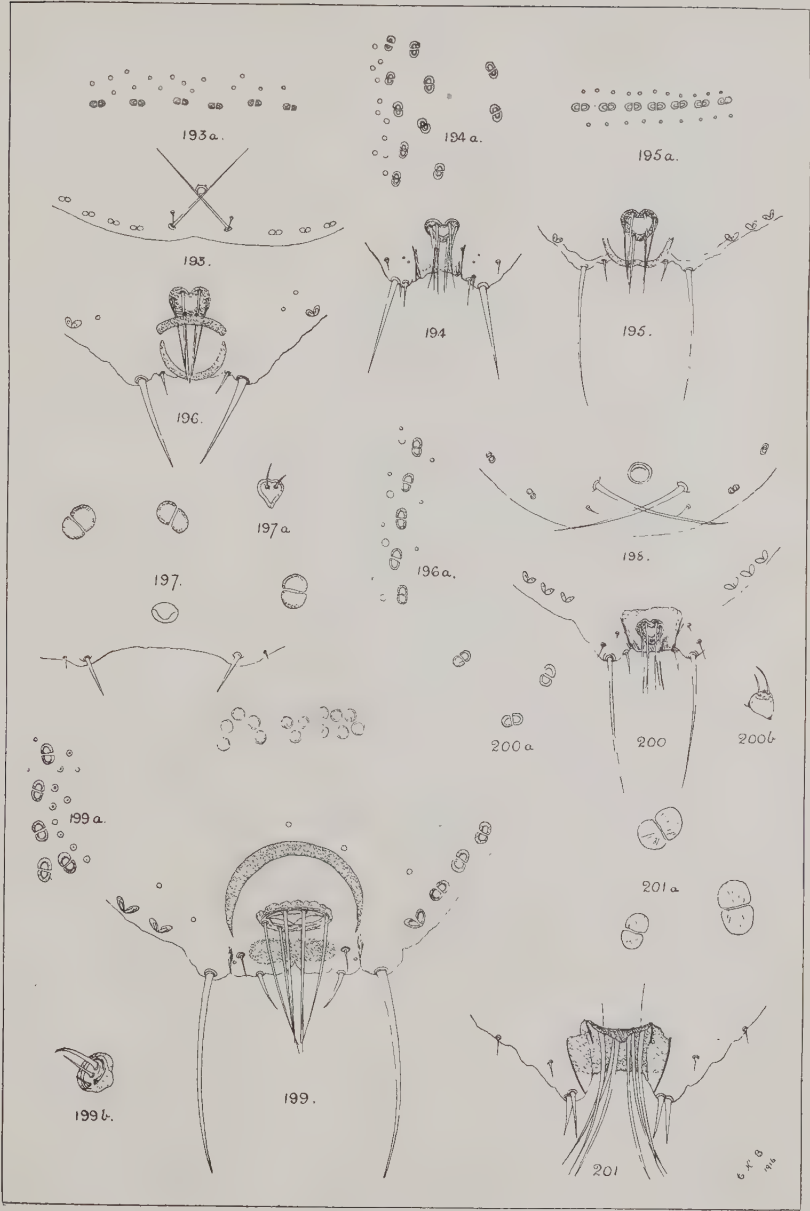






## EXPLANATION OF PLATE VIII.

- Fig. 193. *Asterolecanium variolosum*, Ratz. ; *a*, marginal gland series.
194. „ *pustulans* var. *brachylenae*, nov. ;  
*a*, marginal gland series.
195. „ *bambusae*, Bdv. ; *a*, marginal gland series.
196. „ *conspicuum*, sp. n. ; *a*, marginal gland series.
197. „ *brevispinum*, sp. n. , caudal extremity of ♀ ; *a*, antennal tubercle.
198. „ *borboniae*, sp. n., caudal extremity of ♀ ; *a*, 8-shaped glands of derm ;  
*b*, antennal tubercle.
199. „ *stentae*, sp. n. ; *a*, marginal gland series ; *b*, antennal tubercle.
200. „ *pustulans*, Ckll., caudal extremity of ♀.
201. „ *euryopsis*, Fuller, caudal extremity of ♀ ; *a*, dermal glands.



South African Coccidae.



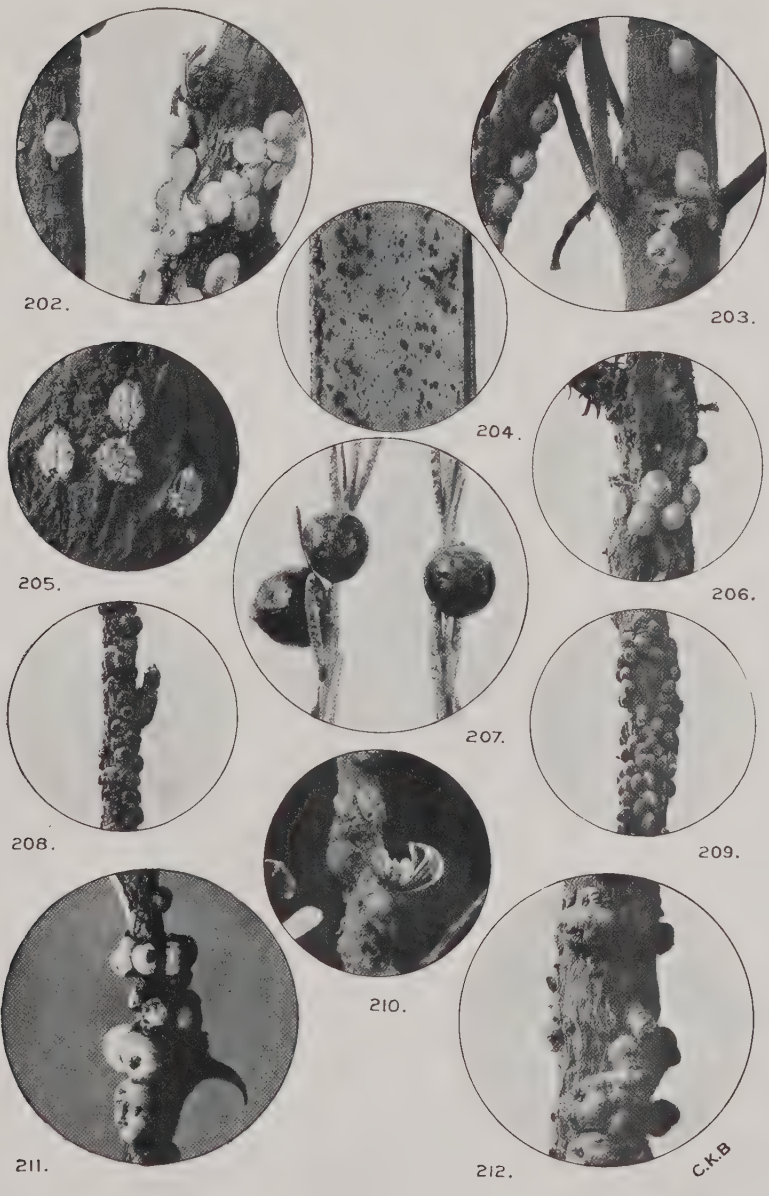




## EXPLANATION OF PLATE IX.

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- Fig. 202. *Lecaniodiaspis mimosae* (Mask.)  
203. „ *tarsalis*, Newst.  
204. *Halimococcus lampas*, Ckll.  
205. *Lecaniodiaspis natalensis*, sp. n.  
206. „ *magna*, sp. n.  
207. *Baccacoccus elytropappi*, sp. n.  
208. *Tachardia actinella*, Ckll.  
209. *Lecaniodiaspis magna*, sp. n. (small form).  
210. *Cerococcus royenae*, sp. n.  
211. *Tachardia albida*, Ckll.  
212. „ *decorella* (Mask.).
-



South African Coccidæ.



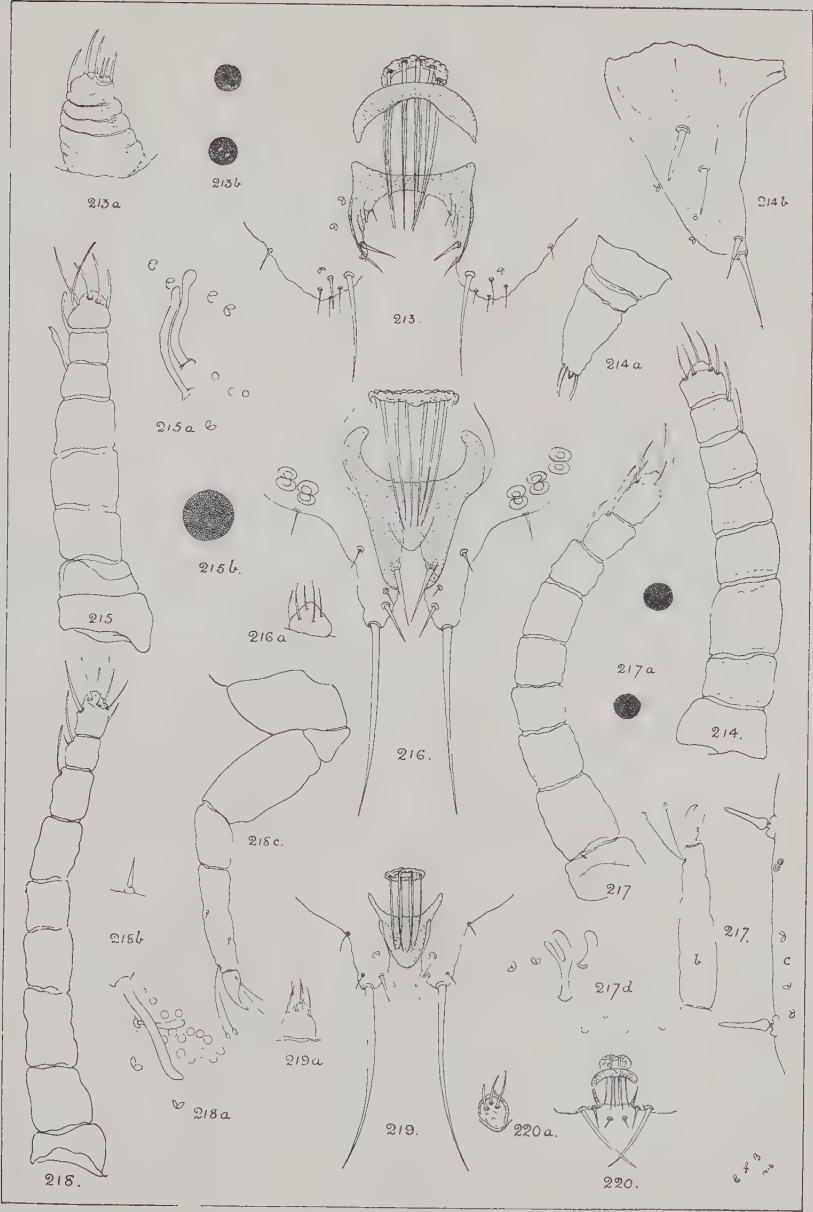




## EXPLANATION OF PLATE X.

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- Fig. 213. *Lecaniodiaspis natalensis*, sp. n. ; *a*, antenna of ♀ ;  
*b*, cribriform plates.
214. „ *magna*, sp. n., antennae of ♀ ;  
*a*, rudimentary leg ; *b*, anal plate, ♀.
215. „ *mimosae* (Mask.), antenna of ♀ ;  
*a*, stigmatic spines ; *b*, cribriform  
plate.
216. *Cerococcus passerinae*, sp. n., caudal extremity ;  
*a*, antennal tubercle of ♀.
217. *Lecaniodiaspis tarsalis*, Newst., antenna ; *a*, cribriform  
plates ; *b*, tarsus ; *c*, marginal  
spines ; *d*, stigmatic spines  
of ♀.
218. „ *brabei*, sp. n., antenna ; *a*, stigmatic  
spines ; *b*, marginal spine ; *c*, leg  
i. of ♀.
219. *Cerococcus ovoides* (Ckll.), caudal extremity ;  
*a*, antennal tubercle of ♀.
220. *Amorphococcus acaciae*, Brain, caudal extremity ;  
*a*, antennal tubercle of ♀.
-



South African Coccidae.

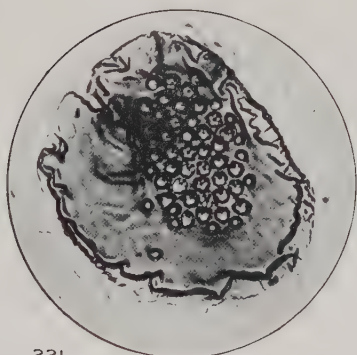






### EXPLANATION OF PLATE XI.

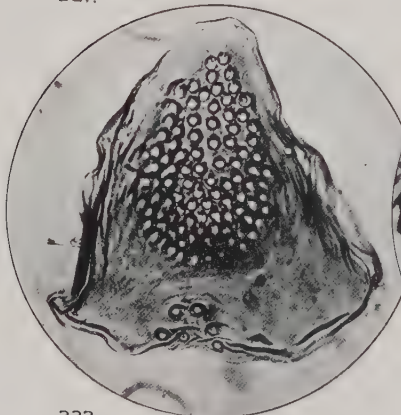
- Fig. 221. *Tachardia actinella*, Ckll., lac-gland plate ; *a*, spine  
of ♀.
222. „ *decorella* (Mask.), lac-gland plate ; *a*, anal  
plate of ♀.
223. „ *decorella* (Mask.), spine of ♀.
224. „ *affluens*, sp. n., spine of ♀.
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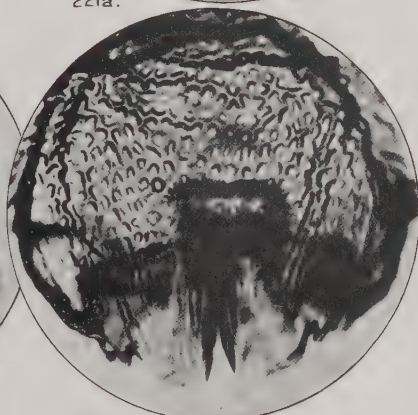
221.



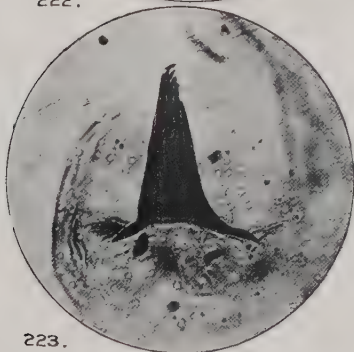
221a.



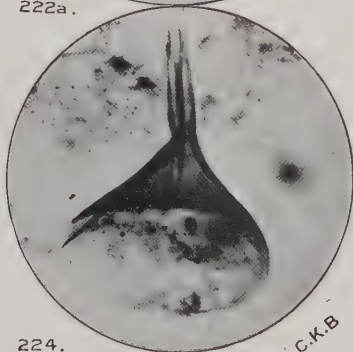
222.



222a.



223.



224.

C.K.B.

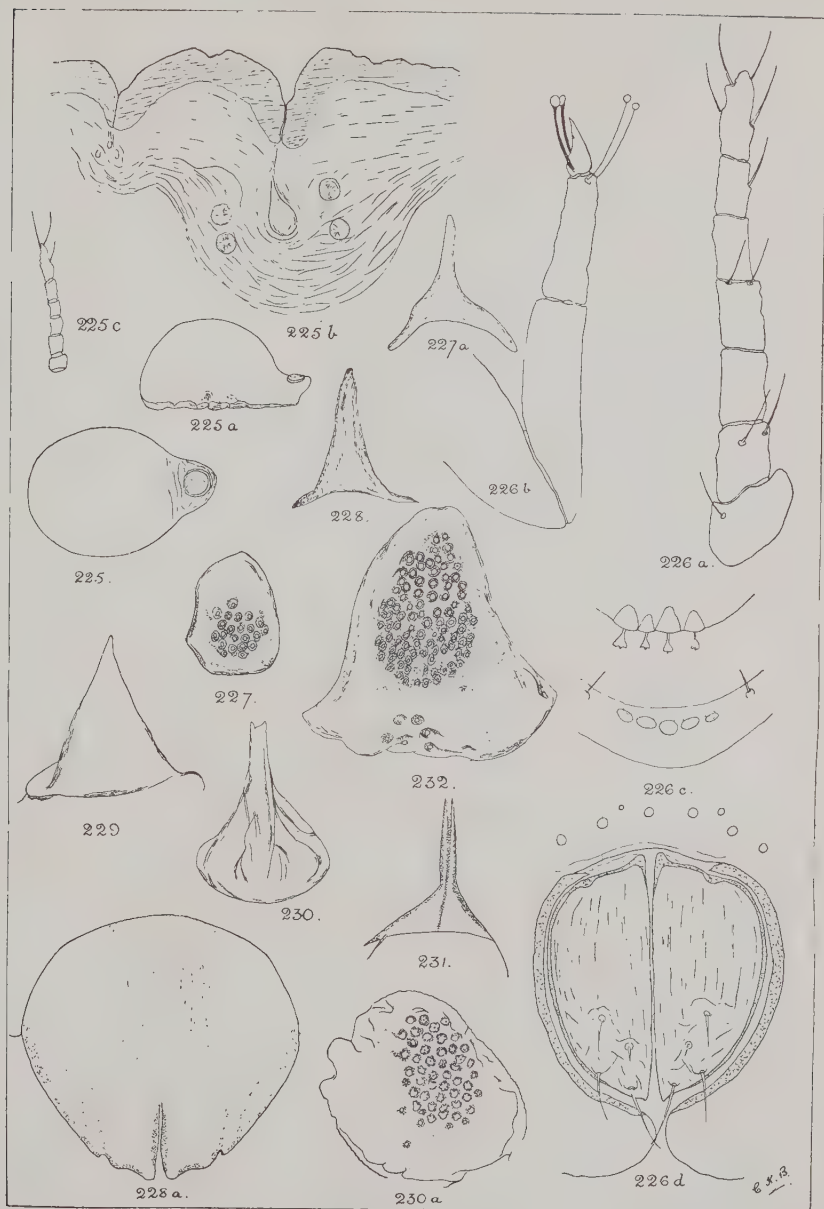






## EXPLANATION OF PLATE XII.

- Fig. 225. *Halimococcus lampas*, Ckll., dorsal view ; *a*, lateral view ; *b*, stigmatic cleft ; *c*, antenna of ♀.
226. *Baccacoccus clytropappi*, sp.n. ; *a*, antenna ; *b*, leg i. ; *c*, stigmatic cleft ; *d*, anal lobes of ♀.
227. *Tachardia minor*, sp. n., lac-gland plate of ♀.
228. „ *decorella* (Mask.), spine ; *a*, anal plate of ♀.
229. „ *actinella*, Ckll., spine of ♀.
230. „ *karroo*, sp. n., spine ; *a*, lac-gland plate of ♀.
231. „ *affluens*, sp. n., spine of ♀.
232. „ *decorella* (Mask.), lac-gland plate of ♀.
-



South African Coccidae.





## MOSQUITO NOTES.

By F. W. EDWARDS.

**Anopheles hyrcanus**, Pallas.*Culex hyrcanus*, Pallas, Reise durch Russischen Reichs, i, p. 175 (1771).*Anopheles sinensis*, Wiedemann, Auss. Zweifl. Ins. i, p. 547 (1828).*Anopheles pictus*, Loew, Dipt. Beitr. i, p. 4 (1845).*Anopheles pseudopictus*, Grassi, Atti R. Ac. Lincei, viii, 1, pp. 102 & 560 (1899).

The salient points in Pallas's brief description are as follows :—"Cinereus . . . Frons hirtella. Antennae triarticulatae ; extremum trinode, basis vero pilis nigris subpennata. Palmi [? palpi] nulli : ensis nudus . . . basi pilosus. Pedes longissimi, grisei, posticis corporis fere tripla longitudine, praesertim tarsi, elongati. Alae lanceolatae, cinerascens, venis hirsutis ad crassiorem marginem nigro maculatae . . . Comes prioris [*C. caspius*, ? = *O. dorsalis*, Mg.], rarior red ferocior."

If we make the highly probable assumption that Pallas described the palpi as the antennae, and that the latter were either broken off or overlooked in his specimen, the above description becomes understandable, since the sentence referring to the "antennae" might very well be used to express the appearance under a low-power lens of the shaggy palpi of an *Anopheles* of the *Myzorhynchus* or *Nyssorhynchus* groups. Although no collections of mosquitos have been made since Pallas's time in the North Caspian region, it is unlikely that any species, other than *A. sinensis*, to which the description could possibly apply, occurs there. The name *hyrcanus* will therefore have to be substituted for *sinensis*.

**Anopheles subpictus**, Grassi.*Anopheles subpictus*, Grassi, Atti R. Acc. Lincei, viii, 1, p. 101 (Feb. 1899).*Anopheles rossii*, Giles, J. Trop. Med. ii, p. 63 (Oct. 1899).

Grassi's short description clearly indicates *A. rossii*, and the fact that he states that his description was drawn up from a specimen sent him by Ross from Calcutta removes any possible doubt which might exist. It is to be regretted that the operation of the rule of priority will prevent the commemoration in zoological nomenclature of Sir Ronald Ross's work.

**Stegomyia fasciata**\* var. **atritarsis**, nov.

Tarsi of fore and mid legs almost entirely black, two or three white scales at the bases of the first two joints ; hind tarsi black, with very narrow white rings (narrower than the diameter) at the bases of the first three and the last joints. White rings on the male palpi narrower than usual. Markings of thorax, abdomen and femora, and structure of male genitalia, normal.

GOLD COAST : Accra, vi. 1919, 1 ♂ 1 ♀ (*Dr. J. W. Scott Macfie*).

Perhaps the most remarkable colour variation yet recorded in this or any mosquito.

\* Dr. Guy Marshall urges the retention of this name, rather than the adoption of the earlier *argenteus*, Poiret, owing to its wide use in medical literature ; a course which has been sanctioned in a few cases by the International Commission on Zoological Nomenclature. With this suggestion I readily concur. The names *Stegomyia* and *Ochlerotatus* though used here as genera are to be understood in a subgeneric sense.

**Ochlerotatus caspius**, Pallas.

*Culex caspius*, Pallas, Reise d. Russ. Reichs, i, p. 475 (1771).

*Culex dorsalis*, Theobald, Mon. Cul. ii, p. 16 (1901) (? *nec* Meigen).

*Grabhamia dorsalis*, Theobald, Mon. Cul. iii, p. 251 (1903).

*Grabhamia subtilis*, Ed. & Et. Sergent, Bull. Mus. Paris, xi, p. 240 (1905).

*Grabhamia willcocksii*, Theobald, Mon. Cul. iv, p. 294 (1907).

*Grabhamia longisquamosa*, Theobald, Ann. Mus. Nat. Hung., iii, p. 102 (1905).

*Mansonia arabica*, Giles, J. Trop. Med. p. 130 (1906).

*Culex arabicus*, Becker, Denkschr. k. Ak. Wiss. Wien, lxxi, p. 140 (1910).

? *Culex maculiventris*, Macquart, Dipt. Exot. Supp. i, p. 7 (1846).

*Culex pulchripalpis*, Theobald, Mon. Cul. ii, p. 13 (1901) (*nec* Rondani).

*Culex penicillaris*, Rondani, Bull. Soc. Ent. Ital. iv, p. 31' (1872) ; Ficalbi, Bull. Soc. Ent. Ital. xxxi, p. 160 (1869).

Recent discoveries (see below, under *O. curriei*) make it appear doubtful whether Meigen's *C. dorsalis* has been correctly determined by Theobald and others, but as it is an abundant species over a wide area of Europe and Asia it is desirable to find a name for it which is not likely to be upset, and I believe that *C. caspius*, Pallas, is such a name. Pallas' original description is of course short and vague, but as he states that the species was abundant and very vicious in the marshes near Guriev (North Caspian) it is probable that he met with one of the common European salt-marsh breeders. The salient phrases in the description, "Color subgriseus, thorace cinereo-fasciato . . . pedes subannulati" would seem to indicate the present species rather than *O. curriei*, while definitely excluding *O. salinus*. Some confirmation of this conclusion has recently been obtained by Capt. P. A. Buxton's discovery of *O. dorsalis*, Theo., at Resht, South Caspian. Pallas' statement that the antennae are "utrique sexu filiformes" may be safely disregarded; and whatever "vaginae multae" may mean, Theobald's translation of "sheath of proboscis snowy white" has obviously no justification whatever.

Large series of this species have recently been received at the British Museum from Italy, Macedonia, Palestine, Egypt and Mesopotamia, which show every gradation in the variation in the colour of the abdominal scales. In some (as in most British specimens) the prevailing colour of the abdomen is black; in the majority the abdomen has pairs of black spots on each segment, or on the anterior segments; while in the palest the black is entirely absent, leaving only the ochreous or whitish ochreous ground-colour. The thoracic coloration varies less; the two white longitudinal lines are nearly always present, though sometimes very narrow; in two specimens from Italy, and in the type of *G. longisquamosa*, they are absent, the mesonotum then being uniformly fawn-coloured. The amount of dark scaling on the wing varies very considerably, but the dark scales are always fairly evenly distributed. No variation is discernible in the male genitalia. The comb-scales of the larvae may or may not have a differentiated terminal spine, a variation which has also been noted by Dyar in *O. curriei*.

**Ochlerotatus caspius** var. **hargreavesi**, nov.

Among a series sent from Taranto, Italy (*E. Hargreaves*), are six females which have the whole of the central area of the mesonotum covered with whitish scales,

though in regard to abdominal markings they agree with moderately dark specimens of the species. Nothing approaching this variation has been seen from elsewhere, and it therefore seems justifiable to distinguish them under a separate name. It will be interesting to find whether any difference exists in the male.

### **Ochlerotatus curriei, Coq.**

*Culex curriei*, Coquillett, Can. Ent. xxxiii, p. 259 (1901).

*Culex onondagensis*, Felt, N. Y. State Mus. Bull. 79, p. 278 (1904).

*Aedes curriei*, Dyar, Insec. Inscitiae Menst. v, p. 122 (1917).

? *Culex punctatus*, Meigen, Klass. i, p. 6 (1804).

? *Culex dorsalis*, Meigen, Syst. Besch. vi, p. 242 (1830).

? *Grabhamia broquettii*, Theobald, Entomologist, xlv, p. 179 (1913).

A small series recently received from Wareham Heath, Dorset (*H. Scott*), proves on close examination to represent a species distinct from the one we have usually known as *dorsalis*, though this latter was taken in company with it and *O. salinus*, Fic. The two forms differ as follows:—

*O. caspius*, Pallas (*dorsalis*, auct.). Scales of mesonotum ochreous brown or fawn-coloured, with two narrow white lines running the whole length. Scales of proboscis mostly pale except towards base and tip. Abdominal scales usually of three colours, black, white and ochreous. Wing scales mostly rather broad, dark ones being evenly spread over all the veins, though in varying proportions with the light ones. Dark scales more numerous on the femora. Apical part of basal lobe of side-piece of male genitalia not prominent.

*O. curriei*, Coq. Scales of mesonotum mostly greyish ochreous; a dark brown band of varying width in the middle, extending only about half way from the front; patches of the same colour on each side in front. Scales of proboscis mostly black. Abdominal scales of two colours only, black and greyish white. Wing scales mostly quite narrow; at the base of the wing they are all pale; dark ones predominate on the apical half of the costa, on the first longitudinal vein, and on the forks of the fourth, while on the third and fifth longitudinal veins the scales are almost all dark; elsewhere they are mostly pale. Femora, except towards tips, almost all pale. Apical part of basal lobe of male genitalia prominent.

Meigen's descriptions of *C. punctatus* and *C. dorsalis* do not apply very well either to *O. caspius* or to *O. curriei*, though they almost certainly must refer to one or the other, and perhaps with more probability to the latter. An examination of the types would be essential to settle the point.

The British examples of *O. curriei* only differ from North American specimens in having the dark scales of the wings rather more numerous, especially on the costa. The male genitalia are identical.

### **Ochlerotatus rusticus, Rossi.**

(*Culex rusticus*, Rossi, Fauna Etrusca, ii, p. 333 (1790).

*Culex pungens*, Robineau-Desvoidy, Mém. Soc. Hist. Nat. Paris, iii, p. 407 (1827).

*Culex quadratimaculatus*, Macquart, Suit. à Buffon, i, p. 34 (1834).

*Culex diversus*, Theobald, Mon. Cul. ii, p. 73 (1901).

*Culex quadratimaculatus*, Villeneuve, Bull. Soc. Ent. France, p. 55 (1919).



On a careful comparison of fresh specimens with Robineau-Desvoidy's description I entirely agree with Dr. Villeneuve in his identification. He has however overlooked the fact that the name *quadratimaculatus* was an unwarranted substitution by Macquart for Desvoidy's *pungens*; moreover I consider it is equally evident from Rossi's description that his *C. rusticus* refers to the more strongly marked form of *diversus* with a continuous median dorsal yellow line. This being the oldest name must replace all the others.

**Ochlerotatus antipodeus, sp. nov.**

♀. *Head* with narrow golden scales in the middle; on each side a patch of narrow black ones, and external to these a small patch of flat white ones; upright scales and bristles blackish, except for a pair of golden bristles directed forwards over the eyes. *Proboscis* and *palpi* black-scaled, the latter about one-seventh as long as the former. *Thorax* dark brown; mesonotum with blackish bristles and dark reddish-brown scales; narrow golden scales arranged in five rather definite lines: one median, extending from the front margin to just before the scutellum, where it forks; a subdorsal pair on the posterior half of the mesonotum; and a lateral pair on the anterior third; some scattered narrow golden scales about the middle, and a patch of the same above the bases of the wings. *Prothoracic lobes* with a few golden scales; area behind them (proepimerum) with small flat blackish-brown ones. *Mid lobe of scutellum* with narrow golden scales in the middle, narrow dark brown ones laterally; lateral lobes with a few narrow dark brown scales. *Pleurae* with patches of flat white scales. *Abdomen* clothed mainly with blackish brown scales; small white lateral basal patches on each segment and narrow yellowish white basal bands on segments 2-5. *Cerci* elongate, blackish. *Legs* black-scaled; femora whitish beneath; narrow white rings on the bases of the first three tarsal joints, broadest on the hind legs, where there are also a few white scales at the bases of the last two joints. *Claw formula* 1.1:1.1:0.0. *Wings* with blackish scales, those in the lateral series almost linear. First fork-cell fully twice as long as its stem, its base a little nearer the wing-base than that of the second. Cross-veins separated by quite twice the length of the posterior one. Halteres yellowish with brown knob.

*Length* (without proboscis), 5 mm.

NEW ZEALAND: Karikari Bay, 5.ii.1916, 14♀ (incl. type) (Albert E. Brookes); Te Horo, near Wellington, 3♀ (received through R. F. L. Burton).

**Ochlerotatus lepidonotus, sp. nov.**

♂. *Head* with a small area of yellowish narrow curved scales in the middle, mixed yellow and black upright forked scales on each side of these, and whitish flat scales more outwardly. *Proboscis* black. *Palpi* longer than the proboscis by the last joint. Long joint mainly pale scaled, but also with many black scales which are specially numerous towards the base and apex; its apical fourth much swollen, with long dense hairs on its outer side, which are orange basally, black apically. Penultimate joint about the size of the swollen portion of the long joint; with whitish scales basally, black-scaled apically; internally and ventrally with long dense orange hairs with black tips; a few shorter stiff black hairs on the outer side

at the apex. Terminal joint slightly longer and distinctly thicker than the penultimate; with whitish scales at the base, otherwise black, black-haired. *Thorax* with black integument; mesonotum with pale yellowish scales and bristles (denuded in middle). Pleurae (except sternopleura) densely clothed with flat whitish scales. Postnotum with a tuft of pale yellowish narrow curved scales apically. *Abdomen* clothed mainly with pale greyish ochreous scales, with some blackish brown ones intermixed to a varying extent; in the darkest specimen the pale scales are confined to rather narrow bands across the bases and apices of the segments, the remainder being all black; venter mainly whitish. *Genitalia*: side-pieces less than four times as long as broad, with rather dense dark brown hairs on the apical half, but none overhanging the harpagones; external margin slightly curved; internal practically straight, except for an indentation just posterior to the basal lobes. Basal lobes very small, with a tuft of hairs, none differentiated; apical lobes barely distinguishable, with a few short hairs. Claspers with a straight and rather stout terminal spine. Harpagones just over half as long as the side-pieces, the stems pubescent, four times as long as the appendage, which is rather narrow, slightly curved and frayed at the tip. Harpes undivided, a little shorter than the stem of the harpagones. *Legs*: femora and tibiae mainly with pale ochreous scales except towards the tips, where the scales are black. Tarsi black, except for numerous pale scales towards the base of the first joint. Claw formula 2.1:2.1:1.1. *Wings* very scantily scaled; the scales brown, except for those on the subcosta, and the base of the costa and first, second, fourth, fifth and sixth longitudinal veins, which are pale yellowish. Fork cells about as long as their stems, the upper with its base much beyond that of the lower.

♀. Palpi nearly a third as long as the proboscis, black, with scattered whitish scales. Scarcely any black scales on the abdomen. Claw formula 1.1:1.1:1.1. Wing-scales rather more numerous, and mostly pale yellowish, except those on the costa and first longitudinal vein.

*Length* (without proboscis), 7-8.5 mm.

MACEDONIA: 4♂ (including type), 10♀, swept in meadow near Galiko R., Salonica, 26. iv. 1918 (*Capt. J. Waterston*).

A very distinct species, with one remarkable characteristic, the possession of scales on the postnotum. In some respects, notably the form of the male palpi, it resembles *O. rusticus*, which, it is interesting to note, was taken at the same time and place.

### ***Ochlerotatus* (Finlaya) echinus, sp. nov.**

*Ochlerotatus lateralis*, Edwards, Bull. Ent. Res. ii, p. 250 (1911) (*nec* Meigen).

*Ochlerotatus ornatus*, Edwards, Bull. Ent. Res. iii, p. 21 (1912) (? *nec* Meigen).

*Ochlerotatus geniculatus*, Edwards, Bull. Ent. Res. iv, p. 49 (1913) (*nec* Olivier).

Differs as follows from the common *O. geniculatus*:—The four dark stripes of the mesonotum are brown instead of black, and are separated by narrow golden, instead of whitish lines; the sides of the mesonotum are almost pure white, instead of yellowish white; the scutellar scales are broad, flat and white; the abdominal segments have narrow basal yellowish bands in addition to the white lateral spots; and the hind femora have a dark dorsal line on the basal half.

MACEDONIA : Stavros, near Salonica, 1918, 1 ♀ (type) reared from larva (*Capt. J. Waterston*). MOROCCO : 1 ♀ caught on horse and mule outside Fez, v. 1909 (*Major C. E. P. Fowler*). ALGERIA : 1 ♀ (*Dr. Sergent*; no data).

In the absence of a male, the best distinctive character which can be adduced is the presence of flat scales on the scutellum; the larva also is very different from that of *O. geniculatus*, hence this form must undoubtedly be regarded as specifically distinct. The Moroccan and Algerian specimens have the flat scutellar scales, but in thoracic markings appear to agree with typical *O. geniculatus*; hence they are somewhat doubtfully conspecific with the type.

### ***Culex apicalis*, Adams.**

*Culex apicalis*, Adams, Kans. Univ. Sci. Bull. ii, p. 26 (1903).

*Culex territans*, Howard, Dyar & Knab, Monogr. iii, p. 293 (1915) (*nec Walker*).

*Culex territans*, Schneider, Verh. Natf. Ver. Bonn, lxx, p. 45 (1913).

*Culex hortensis*, Edwards, Ent. Mo. Mag. (3) i, p. 167 (1915) (*nec Ficalbi*).

*Culex saxatilis*, Dyar, Insec. Inscitiae Menstr. vii, p. 36 (1919).

*Culex pyrenaicus*, Brölemann, Ann. Soc. Ent. France, 1918, p. 427 (1919).

Specimens of *C. pyrenaicus* sent me by Dr. Villeneuve from Rambouillet, France, agree in almost every detail with North American specimens in the British Museum, the only distinction discernible being that the harpagones of the male genitalia are more noticeably serrated on their tips. This difference is so minute that I consider the specific identity of the European and North American forms to be unquestionable, particularly in view of the fact that the male genitalia vary slightly among American specimens.

The species can be readily separated in both sexes from *C. hortensis*, Fic., by the white spots at the tips of the hind femora and tibiae being very small or absent; the wing scales also are perceptibly broader. *Capt. J. Waterston* has recently discovered the larvae of both *C. apicalis* and *C. hortensis* in the neighbourhood of Salonica, and from an examination of his material it can be positively stated that the larva figured by Schneider is that of *C. apicalis* and not of *C. hortensis* as I suggested in 1915.

Dyar, in the paper quoted, discusses the synonymy of the species, and from the evidence he adduces I should certainly conclude that *C. apicalis* is the correct name for the species, *C. testaceus*, v. d. Wulp, being too doubtful to be made use of.

### ***Culex aurantapex*, Edw.**

*Culex aurantapex*, Edwards, Bull. Ent. Res. v, p. 74 (1914).

*Taeniorhynchus domesticus*, Leicester, Cul. of Malaya, p. 169 (1908) (*nec Culex domesticus*, Germar).

I described this species from a single female from Nairobi. Recently a female and three males reared from larvae have been received from Dar-es-Salaam (*A. W. J. Pomeroy*). Although these specimens differ from the type in having slightly broader wing-scales and more numerous pale scales on the wings and legs, there seems little reason to doubt their specific identity with the Nairobi example. They appear to agree in every respect with specimens of Leicester's *T. domesticus*. As Leicester

points out, the wing scales are decidedly narrower than in *C. bitaeniorhynchus*, a difference which, together with a slight distinction in the male genitalia, will probably suffice to distinguish the two forms specifically.

The genitalia are rather peculiar (fig. 1). The apical lobe of the side-pieces has the flat plate much reduced, little more than a flattened bristle; in addition there are four or five undifferentiated bristles and two stout spines. The harpes have only a minute basal appendage. The "harpagones" are divided into two pairs of strong

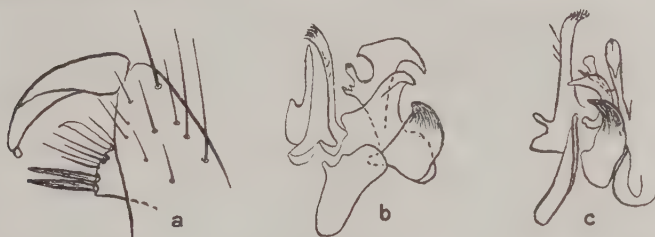


Fig. 1. Male genitalia of *Culex aurantipes*, Edw.; a, apex of side pieces; b, harpes and harpagones, side view; c, the same, dorsal view (one side only).

sickle-shaped plates directed dorsally, the ventral pair is the longer, and gives off ventrally from its base an appendage which divides into a rounded knob and two strong teeth. In the typical *C. bitaeniorhynchus* of the Oriental region, as well as in the var. *ethiopicus*, Edw., this ventral appendage of the second harpagonal plate is much reduced and differently formed.

The var. *ethiopicus* differs from the typical *bitaeniorhynchus* chiefly in having the upper (or basal) sickle-shaped plate of the harpagones much broader than the lower (or apical). The other points of distinction given (Bull. Ent. Res. iii, p. 30, 1912) do not hold good. Specimens of this form were also reared by Mr. Pomeroy at Dar-es-Salaam. The larvae seem to be indistinguishable.

### ***Culex watti*, sp. nov.**

♂. *Head* scales mostly whitish. *Palpi* longer than the proboscis by nearly the length of the last two joints, which are densely hairy. Long joint with a narrow whitish ring before the middle, and another broader one in the middle of the apical half. Last two joints with narrow pale basal rings, creamy above, white below; hairs at tip of last joint also pale; penultimate joint with a short white streak on underside just beyond middle. *Proboscis* brown, with a narrow, distinct though not sharply margined pale ring beyond the middle. *Thorax* brown-scaled, without special ornamentation, except that the scales on and in front of the scutellum and in front of the wing-bases are paler. *Abdomen* dark brown, the segments with dull whitish basal bands of about even width, those on segments 6 and 7 considerably expanded laterally. *Genitalia* (four specimens mounted): side-pieces normal, rather closely resembling those of *C. trifilatus*, Edw. (Bull. Ent. Res. v, p. 64), but the clasper is a little more narrowed apically, and on the lobe the modified bristles in each set of three (anterior to the plate) are of about equal length; the one adjoining the plate has a more flattened tip. *Unci* distinct, pointed. *Harpagones*



with only two incompletely separated divisions, the first sickle-shaped, the point directed ventrally and touching the second, which is broad and flattened horizontally. Harpes with the usual crown of spines, but without any trace of a basal thumb-like projection; their sides straight and parallel. *Legs* brown; femora whitish beneath almost to the tips; a distinct pale spot at apex of hind tibiae, which are also obscurely pale along the inner side; the faintest suggestion of pale rings at the tarsal articulations, most distinct at the junction of the first and second hind tarsal joints. *Wings* with linear-lanceolate brown scales; bases of fork cells practically level.

♀. Resembles the male, but the pale band of the proboscis is much more evident on the underside than above, and is much broader and very ill-defined basally. Middle tibiae in one specimen with a very indistinct pale longitudinal stripe in front.

*Length* (without proboscis), 5 mm.

GOLD COAST: 4♂ (including type) 2♀, Kumasi, 1919 (*Dr. W. G. Watt*).

EAST AFRICA: 4♂ 2♀, Dar-es-Salaam, 30.i.1918 (*A. W. J. Pomeroy*).

The most obvious characters of this species are the banded proboscis and palpi of the male, together with the practically unbanded legs. The specimens agree in most respects with Theobald's description of *C. atæniata*; I have however examined the type in the Liverpool School of Tropical Medicine, and consider it to be only *C. univittatus*, with which indeed the present species might easily be confused.

The genitalia are most distinct, and clearly show that *C. watti* is more nearly related to *C. duttoni* than to any other African species; *C. duttoni* differs chiefly in having the harpagones undivided, elongate, and bent at right angles in the middle. In adult coloration *C. duttoni* differs obviously in the ringed tarsi and striped tibiae.

### **Theobaldia arctica**, sp. nov.

♂. Differs from *T. annulata*, Schrank, as follows:—Palpi rather more slender and darker, both hairs and scales on the last two joints being almost all black. Femora without any trace of pre-apical pale rings; hind tibiae without pre-apical pale patch on the outer side, but with a narrow longitudinal pale streak along the inner side; first tarsal joint of all the legs almost entirely black, only a very few white scales at the base.

*Genitalia*: seventh sternite pointed, with an irregular row of ten stout close-set spines at the tip. Basal lobes of side-pieces small, with two stout bent setae and a number of hairs. Side-pieces also with a distinct pre-apical prominence on the inner side which is densely hairy. Harpes rather slender, more swollen at the tip, where they have four or five small serrations. Harpagones\* rather slender, a little shorter than the harpes, their tips sharply pointed and hooked dorsally. Unci small, pointed, half as long as the harpagones.

N. RUSSIA: 1♂, Archangel, 25.ix.1918 (*Capt. A. G. Carment*).

In coloration and genital structure this insect agrees almost entirely with *T. alaskaensis*, Ludlow, and may in fact be the same. Judging from Dyar and Knab's

\*These are the structures called "unci" by Howard, Dyar & Knab, but as they are undoubtedly homologous with the "harpagones" of *Culex* I use this term for them. The same names are used in quite different senses in different genera of CULICIDÆ, and the terminology of the parts of the male genitalia of these and other Diptera is badly in need of revision and unification.

figure, however, the harpes are differently toothed and the subapical prominences and hair-tufts of the side-pieces are more strongly developed than in *alaskensis*. The genitalia of *T. annulata* differ in the entire absence of stout spines on the seventh sternite and of any preapical prominence or hair-tuft on the side-pieces, and in the differently toothed harpes and less distinctly hooked harpagones.

***Theobaldia indica*, sp. nov.**

Coloration entirely as in *T. arctica*.

*Genitalia*: seventh sternite with a group of about seven short stout spines on its pointed tip. Side-pieces over three times as long as broad: basal lobes and apical prominences practically as in *T. arctica*. Harpes very slender, very little expanded apically, the tip being slightly cleft into two, but otherwise untoothed. Harpagones slightly longer than the harpes and very broad, nearly half as broad (vertically) as they are long; a small sharp, backwardly directed hook on the dorsal margin at some distance before the tip, which is rounded.

PUNJAB, INDIA: 1♂ (type), Bakloh, 28.ii.1900 (*Capt. Lindesay*): 1♀, Umballa, 9.iii.1905, and 1♀, Dalhousie, 4.v.1906 (*Col. H. J. W. Barrow*).

The specimen recorded by Giles (*Gnats*, ed. i, p. 206) from Bakloh is probably this species; the male recorded by Theobald (*Mon. Cul.* i, p. 335) is the type described above. No specimens of the true *T. annulata* from India are in the British Museum collection.



## ON SOME AFRICAN DELPHACIDAE (HOMOPTERA).

By F. MUIR.

Very little is known about the African DELPHACIDAE, especially the tropical forms. For this reason it is worth recording the few species represented in a small collection made by Mr. J. C. Bridwell at Oloke-Meji, Ibadan, Nigeria, in 1914. All the specimens were swept from grasses and reeds. It is to be hoped that larger collections will soon be available and that those who work at them will examine and give figures or adequate descriptions of the genitalia, especially of the aedeagus. Owing to the wide distribution of some species and the great difference in colour of some of the macropterous and brachypterous forms, and to the variation in colour of other species, and the paucity of good specific distinctions in the chroötic characters, it is almost impossible to identify many species of the *Delphacides* group without making use of the phallic characters.

The types of the new species are deposited in the collection of the Hawaiian Sugar Planters' Association, Honolulu, Hawaii. Measurements are from the apex of vertex to anus and from the base to apex of one tegmen.

### **Tropidocephalus brunnipennis**, Sign.

One male and one female from Oloke-Meji. The male genitalia of this specimen are identical with those of specimens from Australia (*T. eximius*, Kirk.)

### **Perkinsiella** sp.

One female, which is closely allied to *P. bakeri*, Muir, from the Philippine Islands, but I fully expect the male to be distinct. This genus in the Pacific is always attached to sugar-cane. It would be of interest to know if this is so in Africa, and to ascertain what parasites keep them in check.

### **Delphacodes disonymos** (Kirk).

*Delphax disonymos*, Kirkaldy (1907), Haw. Sugar Planters' Assn. Ent. Bull. iii, p. 151, line 10, p. 155, Pl. xviii, fig. 4.

*Delphacodes disonymos* (Kirk.), Muir (1917), Proc. Haw. Ent. Soc. iii, 4, p. 333.

*Delphax matanitu*, Kirkaldy (1907), *op. cit.* p. 151, line 13, p. 155, Pl. xvi, figs. 4, 5, Pl. xviii, fig. 15.

*Delphacodes matanitu* (Kirk.), Muir (1917), *op. cit.* p. 333; Muir (1918), *op. cit.* iii, p. 427, fig. 3.

I consider these two species of Kirkaldy's as being the long and short winged forms of the same species. His two figures of the pygofer are drawn from different positions and so appear slightly different; the aedeagi are the same. A similar case of difference in colour of the tegmina is found, I believe, in *D. erectus nigripennis* (Crawford), which I consider to be the brachypterous form of *D. erectus* (Crawford).



**Delphacodes nigeriensis**, sp. nov. (fig. 1).

♂. Macropterous; head slightly narrower than pronotum, vertex as long as base is wide, which is slightly broader than apex, base slightly behind the middle of eyes; first joint of antennae more than half the length of second (1 to 1·7); lateral carinae of pronotum slightly divergingly curved, not reaching to the hind margin: first joint of hind tarsus equal to the other two together.



Fig. 1. *Delphacodes nigeriensis*, Muir, sp. n.;  
a, aedeagus, lateral view; b, right genital style.

Face and clypeus between carinae black, carinae light brown; antennae, vertex, thorax and legs ochraceous tawny, abdomen dark brown. Tegmina hyaline, very light yellowish, veins darker, with sparse minute granules.

Pygofer similar in outline to that of *D. disonymus* (Kirk.), and the genital styles somewhat similar, aedeagus distinct, figured from the right side (figure 1, a); the left side with a row of small spines from a dorso-apical point to the middle; anal styles not so large as in *D. disonymus*, curved and slightly flattened, bases moderately wide apart.

Length, 1·8 mm.; tegmen, 2 mm.

NIGERIA: Oloke-Meji, Ibadan, 1914 (*J. C. Bridwell*).

Described from one male specimen. I consider this to come near to *D. disonymus* (Kirk.), and it is very probable that there is a short-winged form in which the tegmina are dark shiny black.

**Delphacodes bridwelli**, sp. nov. (fig. 2).

♂. Macropterous; head nearly as broad as pronotum, width (including eyes) twice the length; vertex square, base about middle of eye; length of face slightly more than twice the width, slightly narrowed between eyes and at apex; antennae reaching slightly beyond the base of clypeus, first joint about half the length of

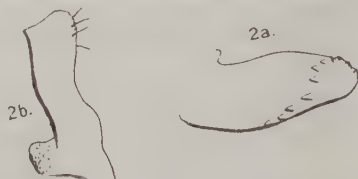


Fig. 2. *Delphacodes bridwelli*, Muir, sp. n.;  
a, aedeagus, lateral view; b, right genital style.

second; lateral pronotal carinae divergingly curved, not reaching hind margin; hind tibiae equal in length to tarsi, first joint of tarsus equal to the other two together. Light brown; black or dark brown between carinae of face and clypeus and over thoracic pleura, coxae and abdomen. Tegmina hyaline, very light brown, veins darker; wings hyaline, veins brown.

Opening of pygofer about as broad as long, dorsal emargination large, anal angles well produced, slightly curved; genital styles straight, outer edge slightly sinuous, inner edge produced into a quadrate process near base, apex truncate; aedeagus flattened laterally, broad, apex rounded, an irregular row of spines from near apex on dorsal aspect across left side to near the medio-ventral area, a somewhat similar row on right side; anal spines large, curved, their bases near together.

*Length*, 2 mm.; *tegmen*, 2.2 mm.

NIGERIA: Oloke-Meji (*J. C. Bridwell*).

Described from one male.

***Dicranotropis bridwelli*, sp. nov. (fig. 3).**

♂. Macropterous; head as broad as prothorax; width twice the length, including eyes; vertex square; length of face nearly twice the width (1 to 1.8), narrowed between eyes and slightly at apex, median carina furcate about middle; length of the first joint of antennae slightly more than half the second, terete. Length of first joint of hind tarsus equal to the other two together; spur as long as first joint of tarsus, thin, concavo-convex, with many small teeth on hind margin.

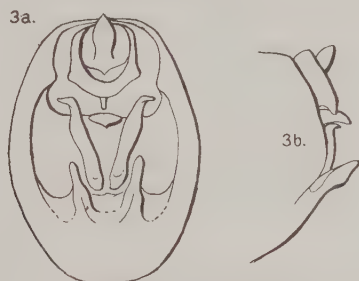


Fig. 3. *Dicranotropis bridwelli* Muir, sp. n.;  
a, pygofer, back view; b, do., side view.

Dark chestnut-brown or black; antennae, carinae on head and thorax, rostrum and legs lighter brown; base of dorsum of abdomen and middle of apical tergite light. Tegmina hyaline, fuscous, a clearer hyaline area over subcostal, radial and median apical cells, veins of the same colour as membrane, granules small, bearing small black hairs; wings hyaline with brown veins.

Pygofer as figured (fig. 3).

*Length*, 2.9 mm.; *tegmen*, 3.8 mm.

NIGERIA: Oloke-Meji, Ibadan, 1914, on coarse grass (*J. C. Bridwell*).

Described from one male specimen. There are two female specimens in the collection which may be this species; they are much lighter, being nearly uniformly light brown.

***Dicranotropis ibadanensis*, sp. nov. (fig. 4).**

♂. Macropterous; head as wide as pronotum, width 2.2 times the length including eyes; vertex square or very slightly wider than long, base slightly behind middle of eye; length of face twice the width, sides slightly curved, narrowest

between eyes and at apex, furcation of median carina one-third from base ; antennae reaching to near middle of clypeus, first joint slightly shorter than second ; first joint of hind tarsus as long as the other two together, spur slightly shorter than first joint of tarsus, with many small teeth on hind margin.

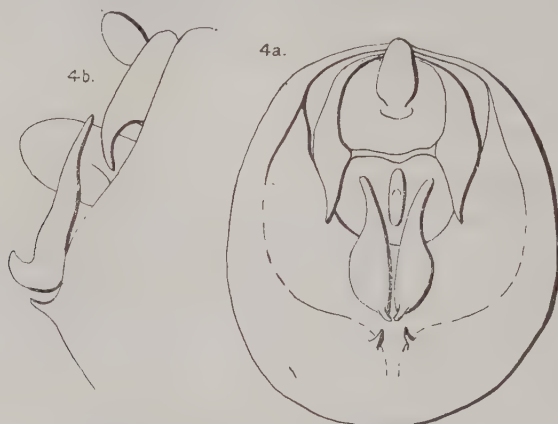


Fig. 4. *Diceranotropis ibadanensis*, Muir, sp. n.;  
a, pygofer, back view; b, do., side view.

Light brown, nearly black over clypeus, coxae and abdomen ; carinae of thorax lighter, traces of lighter spots on face. Tegmina hyaline, a curved, fuscous mark from cross-veins over cubitus extending along veins to the apex of media and cubitus, veins basad of cross-veins yellowish, distad of cross-veins darker, granules few and small ; wings hyaline with brown veins.

Pygofer as figured (fig. 4).

Length, 1.9 mm. ; tegmen, 2.8 mm.

NIGERIA : Oleke-Meji, Ibadan, 1914 (*J. C. Bridwell*).

Described from one male.

#### Genus **Megamelus**, Fieber.

There are a number of closely allied species of this genus having similar facies, with a wide distribution. Only a close comparison of series from various localities will enable one to decide where one species ends and another begins. I sank *M. kolophon* (Kirk.) into *M. furcifer* (Horv.), but I believe it will be better to retain the name as a variety until more material has been studied. I now recognise three varieties of this species, viz. :—

1. *M. furcifer* (Horv.) (fig. 5). The fork at apex of the genital styles small ; clavus with a small black mark at apex.



Fig. 5. *Megamelus furcifer*, Horv., genital style.

6. " *kolophon*, Kirk " "  
7. " *nigeriensis*, Muir, var. n. ; a, aedeagus ; b, genital style.

2. *M. kolophon* (Kirk.) (fig. 6). Fork at the apex of the genital styles much larger; no black mark at the apex of clavus; aedeagus slightly smaller, with smaller spines.

3. *M. nigeriensis*, var. nov. (figs 7 a, 7 b). Fork at apex of genital styles wider and the emargination between them shallower; a dark mark at the apex of clavus.

These forms come near to *Kelisia kirkaldyi*, Muir, and *Kelisia fieberi*, Muir, and eventually will be placed together in the same genus. Until I can revise these genera I prefer to let them remain as they are for the present.

**Megamelus furcifer**, var. *nigeriensis*, nov. (figs. 7 a, 7 b).

♂. Macropterous; length of head, prothorax and mesothorax about 1·5 times the width of the head including eyes, vertex slightly longer than wide; length of face 2·5 times the width, narrowest between eyes, furcation of median carina at extreme base; antennae terete, reaching beyond the base of clypeus, second joint 1·4 times the length of first; first joint of hind tarsus as long as the other two together, spur longer than first joint of tarsus, large, with many small teeth on hind margin. Carinae of face and clypeus, vertex, middle and lateral portions of pronotum, middle of mesonotum, tegulae and base of abdomen yellow; face and clypeus between carinae, medio-lateral portions of pronotum, lateral portions of mesonotum and greater portion of abdomen black; front and middle legs dark brown, hind legs lighter brown. Tegmina hyaline, a dark mark at end of clavus and fuscous over apical veins.

The pygofer is similar to that of *M. kolophon*, Kirk.,\* but the genital styles are wider at the apex and not so deeply indented, the aedeagus is slightly larger and the spines stronger.

Length, 2 mm.; tegmen, 2·3 mm.

NIGERIA: Oloke-Meji, Ibadan, 1914 (*J. C. Bridwell*).

Described from two males.

**Megamelus flavolineatus**, sp. nov. (fig. 8).

♂. Macropterous; width of head including eyes 1·6 times the length, nearly as wide as the pronotum; length of vertex 1·4 times the width; antennae reaching beyond the base of clypeus, first joint more than half the length of the second

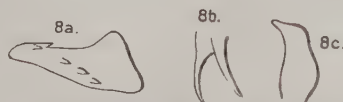


Fig. 8. *Megamelus flavolineatus*, Muir, sp. n.; a, aedeagus; b, anal spines; c, genital style.

(1 to 1·7); length of face 2·5 times the width, slightly narrowed between eyes, sides subparallel, median carina forked at middle of face; first joint of hind tarsus as long as the other two together, spur nearly as long as the first joint of tarsus, large, thin, with many small teeth on the hind margin.

\* Haw. Sugar Planters Assn. Ent. Bull. iii, pl. xv, figs. 9-10.



Dark brown or black; vertex, carinae of head, middle and lateral margins of pronotum, middle of mesonotum, tegulae, antennae and legs yellow or light brown. Tegmina hyaline, veins yellow or light brown, a dark mark at apex of clavus, fuscous over apical portion of cubital veins.

Aedeagus short, deep at base where it is laterally compressed, a row of three or four spines on the right side and another somewhat similar row on the left; anal spines large, slightly curved and pointed; genital style as figured (fig. 8. c).

*Length*, 1.8 mm.; tegmen, 2.5 mm.

♀. Macropterous; similar in colour to the male.

*Length*, 2.0 mm.; tegmen, 3.0 mm.

NIGERIA: Oloke-Meji, Ibadan, 1914 (*J. C. Bridwell*).

Described from six males and eleven females. Some of the specimens are lighter in colour than the type, especially between the carinae of clypeus and genae.

### ***Phyllodinus badius*, sp. nov.**

♀. Macropterous; head as wide as pronotum, width 2.4 times the length; vertex wider than long; length of face double the width, narrowest between eyes and at apex, median carina furcate slightly distad of middle; antennae terete, reaching slightly beyond the base of clypeus, first joint slightly shorter than second; femora and tibiae of first and second legs and femora of hind legs flattened and expanded; lateral pronotal carinae divergently curved, not reaching the hind margin. First joint of hind tarsus equal in length to the other two together; spur as long as first joint of tarsus, many small teeth on hind margin.

Dark chestnut or nearly black; carinae of head and thorax, second joint of antennae, middle and lateral margins of pronotum, middle of mesonotum, four or five pairs of small spots on face, middle and hind femora and hind tibiae lighter brown. Tegmina hyaline; before the cross-veins the veins are light narrowly bordered with brown, with small light granules; beyond the cross-veins the veins are of the same colour as the membrane, which is brown over the cubital area and over the radial apical veins, spreading into the membrane; wings hyaline, with brown veins.

*Length* 2.9 mm.; tegmen, 4.0 mm.

♀. Brachypterous; colour similar to the macropterous form. As in most brachypterous Delphacids the reduction is mainly in the apical cells. The middle of the membrane between the veins is raised in longitudinal ridges, giving the tegmina the appearance of having numerous veins.

*Length* 2.7 mm.; tegmen, 2.00 mm.

NIGERIA: Oloke-Meji, Ibadan, 1914 (*J. C. Bridwell*).

Described from two macropterous and one brachypterous females, the type being one of the former. The second macropterous specimen is darker than the type.

## INSECTS INJURIOUS TO ECONOMIC CROPS IN THE ZANZIBAR PROTECTORATE.

By W. MANSFIELD-ADERS,

*Government Economic Biologist, Zanzibar.*

(PLATES XIII–XV.)

The following notes on the various insects injurious to the economic crops of the Zanzibar Protectorate are based on investigations made during the last few years.

The chief economic products of the two islands (Zanzibar and Pemba) are cloves and coconuts, the former being of greater importance.

### INSECTS AFFECTING CLOVES.

Fortunately no insect pests of the clove tree (*Eugenia caryophyllata*) have been discovered, but it is apparent in many plantations that a number of trees are unthrifty and die. The cause of death still remains uncertain, but most of the evidence points to some physiological condition, such as waterlogging of the roots near swamps, denudation of alluvial soil on slopes, or the tap-root reaching an impervious layer of stone. The bark of certain unhealthy trees is attacked by termites (*Termes bellicosus*) and dead branches are infested with various species of Bostrychid beetles. Some young clove trees from Pemba had been killed by *T. bellicosus* feeding on the bark of the lateral roots.

The adults of a large Tenebrionid beetle, *Pycnocerus passerinii*, Bertol., have been found on several occasions lurking under dead bark on clove trees, while larvae and pupae occur in deep tree-holes filled with decomposing vegetation: I am of opinion that they do no actual damage, but only feed on dead bark, etc.

Several experiments have been undertaken to test whether various omnivorous Lepidopterous larvae, such as those of *Euproctis producta*, would feed on clove trees when deprived of other food, but all died.

### INSECTS AFFECTING COCONUTS.

*Oryctes monoceros* and *O. boas*. These two rhinoceros beetles are common throughout the two islands and are a serious menace to the coconut industry, the former being the commoner species. The damage done to young trees is often very serious: in some plantations more than half of the trees from 2½ to 3 years old are killed, while others are stunted and their productiveness much reduced. A certain number of trees survive initial attacks, but as their growth is retarded, they take a long time to reach maturity. Mature trees rarely succumb to the attacks of the beetles, although a number of felled trees were found to harbour the insects.

The following record of the life-history of *Oryctes monoceros* has been obtained:—

Eggs found in dead coconut trunk	..	..	..	11. viii. 1917.
Eggs hatched	..	..	..	19. viii. 1917.
Larvae started to build pupal cell	..	..	..	5. xii. 1917.
Pupal cell completed and pupa formed	..	..	..	10. xii. 1917.
Adults emerged	..	..	..	28. xii. 1917.

It will be seen from this that the length of the larval life is 113 days, that of the pupa 18 days.

After the mature larvae had built their pupal cell they shrunk considerably in size and became very sluggish before pupating; this period of inertia lasted 5 days.

Pupae are often found in association with larvae in old coconut trunks, generally among the coarse fibres where disintegration has not yet taken place; the larvae prefer the centre, where the fibres have been reduced to the consistency of a warm moist debris.

The larvae of *Oryctes boas* are more usually found in rubbish heaps composed of decomposing vegetable matter and manure. I have found manure heaps riddled with larvae of all ages; horse and donkey droppings seem the most attractive.

The following preventive measures have been tried :—

(1). Traps have been set in various localities filled with rotting coconut trunks, decaying vegetation, etc.; the addition of a little horse manure enhances their attractiveness and they have given excellent results.

(2). The collection of adults and larvae by natives has been tried in East Africa, but the results were not encouraging.

(3). In small plantations the daily examination of all young trees (from 2½ to 3 years old) for adult beetles should be quite efficacious. The easiest method is to insert a small piece of wire with harpoon points into the entrance hole, transfix the beetle and withdraw it. After a little experience the palms harbouring beetles are easily recognised by the moist tow-like frass protruding from the entry holes. Sprinkling dry earth or sand in the crowns of the young trees may possibly act as a deterrent to adult beetles. There is no doubt that bare plantations and isolated trees are more severely attacked, probably because the beetle being a heavy sluggish flier is able to alight more easily on its food-plant under these conditions. The planting of some tall bushy catch-crop, such as *Cajanus indicus*, around the plantation might be efficacious.

Some imported larvae infected with a fungus (*Metarrhizium anisopliae*) were received, and it was proved that our local larvae are susceptible to the disease; further, in some control experiments one case of actual indigenous infection was found. A long series of experiments with a view to introducing this fungus was planned, but owing to unforeseen circumstances all work in this direction was abandoned.

I have on several occasions seen young trees suffering from what might be called bud-rot. The whole of the crown is easily pulled out leaving a hollow depression full of dark fluid with a most foetid odour. It may perhaps be proved later that bud-rot is secondary to the attacks of the beetle.

To summarise the above :—The rhinoceros beetles (*Oryctes monoceros* and *O. boas*) are common throughout Zanzibar and Pemba, and are the most serious pests of the coconut industry. Young trees from 2½ to 3 years old are most usually attacked, many are killed, others greatly delayed in reaching maturity. Trees in isolated positions and on bad soil are more often attacked. Fully matured trees harbour adult beetles, but the damage to them is not serious. The most useful preventive measure is the trapping of larvae in pits filled with rotting coconut trunks, vegetable debris and a little manure.

No insect parasites have been found preying on the eggs, larvae, pupae or adults.

Among mammals the most useful in destroying larvae are the MACROSCELIDAE and SORICIDAE. The following list includes all known to me.

*Rhynchocyon adersi*. A large elephant shrew, which is somewhat local in its distribution and chiefly found in scrub on the east coast of the island. It has not been observed feeding on larvae under natural conditions, but partook of them greedily in captivity.

*Petrodomus sultan*. A rare species, concerning the habits of which no observations have been obtained.

*Pachyura murina*. These small shrews are widely distributed throughout the island and have been found in beetle traps on several occasions.

Two species of crows (*Corvus scapulatus* and *Corvus splendens*) have been noticed feeding on the larvae of *Oryctes boas* in manure heaps. Many species of birds have been collected and their stomachs carefully examined for larvae or fragments of adults, but none have been found.

The following are minor pests of coconut palms :—

### **Rhynchota.**

*Aspidiotus destructor*, Sign. This dangerous coconut scale-insect has been found occasionally on husks and leaves, but at present does no appreciable damage.

*Aspidiotus cyanophylli*, Sign., *A. lataniae*, Sign., and *Hemichionaspis minor*, Mask., have all been found on the husks of coconuts in association with *Aspidiotus destructor*.

*Cerataphis lataniae*, Licht. This cosmopolitan Aphid has been found frequently on the leaves of coconut palms but never in great numbers. Ornamental palms of various varieties are heavily infested.

### **Coleoptera.**

*Rhina amplicollis*, Gerst. Adults, larvae and pupae of this large weevil were found in a dead coconut tree in Pemba.

*Diocalandra frumenti*, F. These small Curculionids were found in numbers in crevices on coconut husks. The infested nuts showed in the majority of cases cracks and fissures from which gum was exuding. Attention had been drawn to the trees on account of the shedding of immature nuts and peculiar deformities in the shape of the nut, but it is by no means certain that the injuries were due to the weevils, which were probably secondary visitors.

*Rhynchophorus phoenicis*, F. This large weevil has been recorded from Pemba. Larvae, pupae and adults were found in an old stump of a coconut tree, others in a dead oil palm (*Elaeis guineensis*). As far as can be ascertained at present it is not a serious pest of coconuts.

### **Isoptera.**

*Termes bellicosus*, Smeath. Termites often attack seed-beds and cause great havoc among the nuts, in some instances 50% of them having been destroyed. The soaking of nuts in Cooper's dip before planting gave good results. Mr. T. J. Anderson, Government Entomologist in British East Africa, advised watering the seed-beds with sea-water, but as the beds attacked were situated inland a considerable distance from the sea, the method has not been tested.



## INSECTS AFFECTING COTTON.

A few experimental plants of the following varieties have been grown, viz., Egyptian :—Abassi, Nubari, Yannovitch, Mit Affifi, Asili, Sakellarides ; American :—Allen's Long Staple and Sunflower.

All the plants were heavily infested by a variety of insects of which the following proved the most injurious.

**Lepidoptera.**

*Pectinophora (Gelechia) gossypiella*, Saunders. This has proved to be the most serious pest, as every variety of cotton was attacked. All stages of development were taken throughout the year. Other food-plants were the silk-cotton tree (*Eriodendron anfractuosum*) and Ladies' Fingers (*Hibiscus esculentus*), the latter plant being always heavily infested.

*Pyroderces simplex*, Wlsm. Some adults emerged from stored seed.

*Earias insulana*, Boisd. A few specimens were obtained from all varieties of cotton. A very common pest of *Hibiscus esculentus*.

*Sylepta derogata*, F. This leaf-roller occurred abundantly on all varieties and was responsible for serious damage.

*Prodenia litura*, F. Remarkably few larvae were found. Other food-plants are *Hibiscus esculentus*, young tobacco plants, castor plants, and on one occasion a ripe tomato fruit.

*Acrocerops bifasciata*, Wlsm. Cotton plants of all ages were attacked by this leaf-miner. The attacked leaves have a very characteristic appearance, the whole of the upper epidermis being raised to form one large blister.

*Bucculatrix loxoptila*, Meyr. Larvae were taken feeding on the upper epidermis of Abassi cotton ; they construct a tough white cocoon shaped like an upturned boat on the leaf.

*Orygia vetusta*, Hmp. One small swarm of larvae appeared, completely defoliating the attacked plants.

*Euproctis producta*, Wlk. Larvae occasionally swarm on cotton ; they are omnivorous, moving from one food-plant to another, castor oil plants seeming to be their favorite food.

**Rhynchota.**

*Dysdercus fasciatus*, F. This stainer was prevalent during the bolling season and caused much damage to the lint ; all varieties of cotton were attacked, especially Caravonica. These insects were observed plunging their proboscis into young oily seeds in bolls which had opened prematurely. They were also seen on many occasions feeding with avidity on fresh mammalian carcasses, skins and skulls.

*Dysdercus supersticiosus*, F. This has been taken occasionally, but is by no means a common species.

*Orycaremus albidipennis*, Stål. All instars are common in well matured open bolls. In neglected crops they occur in vast numbers, although the actual damage done seems to be negligible.

*Pseudococcus obtusus*, Newst. At times this is a serious pest. It is one of the commonest Coccids of the island and feeds on a variety of hosts. Many experimental plants of cotton were completely covered, the main stem being smothered.

*Pseudococcus virgatus*, Ckll. Found occasionally on leaves and beneath the sepals. This Coccid is very abundant on a number of ornamental plants and shrubs.

*Pseudococcus citri*, Risso. A rare species on cotton.

### INSECTS AFFECTING CEREALS.

The principal cereals cultivated are rice, maize, and millet (*Sorghum vulgare*), none of them in any great quantity.

#### Lepidoptera.

*Cirphis loreyi*, Dup. The larvae of this Noctuid are common in all maize fields. They bore and tunnel through the main stalk, attack the base of the cob, and occasionally feed on unripe seeds. Pupation takes place either in the stalk or in the cob. The moist white excrement, very typical of the presence of the larva, is generally found at the base of the leaves or cob. The large exit holes of the imago are easily detected. The species also attacks millet.

*Sesamia calamistis*, Hmp. Very similar in its habits to *Cirphis*. In young cobs the tassel is often attacked, the larvae working downwards into the cob ; it likewise feeds on millet.

*Basseola fusca*, Hmp. Larvae and pupae were found in the main stalk of millet, but never in great numbers.

*Chilo suppressalis*, Wlk. This species is the commonest borer of maize and the most harmful, as in some instances it will destroy a full half of the crop ; it also attacks millet.

*Parnara mathias*, F. Larvae of this butterfly have been found occasionally feeding on the leaves, but as a pest it is insignificant.

#### Rhynchota.

*Peregrinus maidis*, Ashm. A field of imported maize (Hickory King) was found heavily infested with this cosmopolitan pest ; but the common native variety of maize is rarely attacked.

### INSECTS INJURIOUS TO VEGETABLES.

#### CABBAGES.

*Crocitolomia binotalis*, Z. Cabbages are always heavily infested with the larvae of this moth and several valuable crops have been completely ruined. Pupation takes place on the leaf under a light silken web or in the rolled end of a leaf. The pupal stage averages 10 days. Other food-plants are turnip, watercress, radish and nasturtium.

*Plutella maculipennis*, Curt. The small brilliant green larvae of the diamond-back moth were taken in conjunction with those of the former species. Pupae are found on the leaf in a silken web.

*Phytometra signata*, F. This moth is a minor pest.

EGG PLANT (*Solanum melongena*).

*Acanthocoris fasciculatus*, F. This bug is a serious pest. In many market-gardens these useful plants are smothered with it; the tips of the young shoots wilt quickly when heavily infested. It occurs as a minor pest of the chilli (*Capsicum* sp.).

## CUCURBITACEAE.

*Dacus vertebratus*, Bezzi. The larvae of this fruit-fly are extremely common in all varieties of native gourds and cause a large amount of damage. Other food-plants are *Luffa acutangula* and various squashes. Market-gardeners have attempted to grow melons and cucumbers, but very few reach maturity owing to the ravages of this fly.

Two other species of *Dacus* also occur in gourds, *D. brevistylus*, Bezzi, and *Dacus punctatifrons*, Karsch.

PIGEON PEA (*Cajanus indicus*).**Rhynchota.**

*Pseudococcus obtusus*, Newst. This insect, one of the commonest Coccids of the island, is found in enormous numbers on this useful plant.

**Coleoptera.**

*Tragocephala variegata*, Bert. Adults of this Longicorn are prevalent during the hot season from October to March. Eggs found in the field in April hatched in 10 days; larvae have been kept in captivity for 3 months without pupating: pupae taken in the field produced imago in 12 days. The female gnaws a small hole in the bark of a lateral branch and there deposits an egg. The larvae feed for a short time in this branch, then tunnel down the main stalk, making many vent holes during their transit and eventually pupating in a plugged cell low down in the trunk or even in the root. A large exit hole denotes the escape of the adult.

*Lypros brevisculus*, Gerst. Numbers of these beetles have been found feeding on the peas. All instars are present in the pods. They are generally found in neglected fields where old pods have been left on the trees.

Several species of MELOIDAE feed on the leaves but are only minor pests. The following have been identified;—*Mylabris dicincta*, Bert., *Mylabris amplexans*, Gerst., and *Coryna ambigua*, Gerst.

**Lepidoptera.**

*Marasmarcha atomosa*, Wlsm. These small delicate moths have been taken towards dusk hovering around the pods. The characteristic larva, studded with spines and hairs radiating from tubercles, feeds through a hole on the pea. The pupa closely resembles the larva and is generally found on the outside of the pod.

*Deudorix antalus*, Hopff. The large flat conspicuous larvae of this butterfly are an occasional pest of the pigeon pea. They are voracious feeders and attack the seeds in young green pods with avidity, at times causing a considerable amount of damage. Pupation takes place in the pod.

**Diptera.**

*Agromyza* sp. The larvae of this fly attack the young green seeds in the pod, making a ring-like track around the seed ; the pupae are formed within the pod.

LADIES' FINGERS (*Hibiscus esculentus*).

These useful plants harbour a number of important insect pests of which the following have been recorded:—*Pectinophora gossypiella*, *Earias insulana*, *Sylepta derogata* and *Prodenia litura* ; as previously mentioned all of these occur on cotton.

*Nisotra weisei*, Jac. Numbers of these small flea-beetles swarm on the leaves, giving them a typical shot-hole appearance. The same species has been found on roselle (*Hibiscus sabdarriffa*).

SWEET POTATO (*Ipomoea batatas*).

*Cydias formicarius*, F. This cosmopolitan weevil is a common pest throughout the two islands, many tubers being completely riddled and destroyed. All instars are found in the tubers.

*Aspidomorpha puncticosta*, Boh. The leaves are often severely attacked by the larvae of this Cassidid beetle, which are conspicuous on account of their long anal process.

CASSAVA (*Manihot utilissima*).

This useful plant, the chief food supply of the natives, is exceptionally free from pests.

*Pseudococcus* (*Dactylopius*) *virgatus* var. *madagascarensis*, Newst. A few plants have been observed to be infested with this Coccid.

*Tetranychus* sp. This small red mite is abundant in some plots, and causes wilting and curling of the leaves.

## INSECTS INJURIOUS TO FRUIT TREES.

## CITRUS.

**Rhynchota.**

*Lepidosaphes beckii*, Newman. This scale-insect is the worst enemy of *Citrus*, and in many plantations the trees are thickly encrusted. The main stem and laterals are the favourite sites, but leaves and fruit are also attacked. I have seen numbers of oranges packed ready for export infested with this scale.

*Icerya purchasi*, Maskell. Fortunately very few trees are attacked by this Coccid, which at present is quite a minor pest.

*Icerya seychellarum*, Westw. Has been observed on lemons.

*Pseudococcus obtusus*, Newst. This Coccid has been taken on all varieties of orange, in addition to its other food-plants.

*Pseudococcus citri*, Risso. A minor pest which has never been found in abundance.

*Ceroplastes rubens*, Maskell. One record from a young orange tree.

*Coccus viridis*, L. This scale is very prevalent on young trees in some plantations and shows a marked partiality for imported species of *Citrus*.



*Aspidiotus (Pseudonidia) trilobitiformis*, Green. Occasionally met with; this Coccid has a variety of hosts.

*Cerataphis lataniae*, Licht. This is another of the commonest citrus pests; the leaves of many trees both old and young were found to be heavily infested. This Aphid is also abundant on many varieties of ornamental palms.

*Aphis tararensis*, del G. The black cotton aphid is extremely seasonal in its occurrence and is generally found on the leaves and young tender shoots.

### Lepidoptera.

*Argyroplote leucotreta*, Meyr. (Citrus Codling Moth). Larvae have been found on several occasions in mandarins, but not in oranges.

*Papilio demodocus*, Esp. A very common pest on all young citrus trees. Many young plants are completely defoliated, and the larvae are occasionally found feeding on tender shoots of mature trees.

### Coleoptera.

*Tragocephala variegata*, Bert. The habits of this Longicorn have been described under pests of the pigeon pea. It attacks all varieties of *Citrus*.

*Porphyronota maculatissima*, Boh. A few adults of this unimportant Cetoniid beetle have been taken from time to time feeding on the leaves.

*Gymnynchus cervinus*, Gerst. A number of adults of this weevil have been obtained, they attacked the leaves of young orange trees; a minor pest.

### Diptera.

*Ceratitis capitata*, Wd. This serious pest does not seem to be very widespread. Oranges and mandarins of imported varieties were found to be infested, but indigenous trees (oranges, mandarins and lemons) are far less susceptible to the attacks of this fruit-fly.

### MANGOS.

*Sternochetus (Cryptorrhynchus) mangiferae*, F. Adults are commonly found in the stone of the fruit, larvae and pupae in fallen immature fruit.

The following COCCIDAE have been found on the leaves and fruit: *Aspidiotus (Chrysomphalus) dictyospermi*, Morg., *Aspidiotus destructor*, Sign., *Pseudococcus obtusus*, Newst., *Lecanium adersi*, Newst., *L. (Saissetia) nigrum*, Nietn., *L. (Saissetia) punctuliferum*, Green.

Of these the only one of importance is *Pseudococcus obtusus*, which heavily infests both the leaves and fruit of many trees.

### BANANAS.

*Aspidiotus destructor*, Sign. Has been found occasionally both on the fruit and leaves.

### SOURSOP.

*Ceratitis rosa*, Karsch. One fruit was found to harbour larvae of this fly.

## INSECTS AFFECTING SHADE TREES.

**Lepidoptera.**

The African almond (*Terminalia catappa*) is common throughout the two islands and is much appreciated for its ornamental foliage and shade properties. In certain situations, especially in the town, it is severely attacked by bag-worms (PSYCHIDÆ). Unthrifty trees are heavily infested, most of the leaves being almost skeletonised.

*Miresa melanosticta*, Baker. A minor pest of the African almond. The large green slug-like larvae with lateral tubercles are not easily detected in spite of their size. They have the peculiar habit of arranging themselves in circles on the leaves, their heads facing inwards. Pupation takes place in the soil in a hard round cocoon, with a distinct lid.

*Cirina forda*, Westw. The larvae feed on young casuarina trees (*Casuarina equisetifolia*) and are easily detected by their conspicuous yellow markings. Pupation takes place in the soil at a depth of about 3 inches. Another food-plant is the naseberry.

*Asura saginaria*, Wlk. The larvae of this moth have been taken occasionally on cinnamon trees, but it is quite a minor pest.

**Rhyncho.**

*Pseudococcus obtusus*, Newst. When in poor soil casuarina trees are often heavily infested with this scale-insect, the lower branches being principally attacked.

*Aspidiotus (Pseudonidia) trilobitiformis*, Green. Many rubber trees (*Ficus elastica*) are heavily infested with this Coccid.

*Dysdercus supersticiosus*, F. The open bolls of the silk-cotton tree (*Eriodendron anfractuosum*) are often attacked by this common cotton-stainer, and *D. fasciatus* is found in conjunction with it.

## INSECTS AFFECTING TIMBER.

**Coleoptera.**

*Macrotoma palmata*, F. The larvae of this Longicorn are a serious pest in the mangrove wood rafters in native huts. On one occasion several larvae were extracted from large tunnels which they had made in a piano case. Numbers have been found in the field in old dead mango stumps.

*Dinoderus minutus*, F. Extremely common and destructive to dried bamboo and a very serious pest. Adults have been found in Madagascar teak, a slight attack. On one occasion the bark of an avocado pear (*Persea gratissima*) was found to be heavily infested with it.

**Isoptera.**

*Termes bellicosus*, Smeath. Ubiquitous in its distribution, the white ant is the worst timber pest of the two islands. Imported European soft woods are reduced to ruin in a few years, though Indian teak is rarely attacked. The structural timber of the native huts (mangrove, *Ceriops candoliana*) and the roofing made of plaited coconut leaf are often attacked.

Termites have been reported as injuring the following living trees: Seed and seedling coconuts, young avocado pears (the roots badly attacked), and cloves.

## INSECTS INJURIOUS TO MISCELLANEOUS PLANTS.

**Lepidoptera.**

*Thalassoides digressa*, Walk. The larvae occasionally feed on the leaves of the castor plant.

*Duomitus capensis*, Wlk. The larvae have been found tunnelling in the main stem of the castor plant.

*Brithys pancratii*, Cyr. The caterpillars are voracious feeders on all species of lilies; when young they are gregarious and feed under the epidermis of the leaf, later they separate and devour the whole plant. Pupation takes place in the soil or at the base of the leaves, the pupal stage averaging from 8 to 10 days.

*Euclromia formosa*, Guér. The larva is clothed with tufts of hairs, dull-coloured and inconspicuous, and forms a cocoon of silk and hairs on the branches of the food-plant. It is common on all species of creepers belonging to the genus *Ipomoea*.

*Glyphodes sericea*, Drury. The larvae are common on gardenias. Adult larvae are of a transparent green colour with four black spots on the dorsum. They are leaf-rollers and live and pupate in twisted leaves, their pupal stage averaging 9 days.

**Coleoptera.**

*Entypopsis impressa*, Kolbe. Larvae of this weevil have been recorded as feeding on the roots of castor plants and caladiums.

*Bruchycerus atrox*, Gerst. Great numbers of adult weevils have been taken in the soil around the tubers of lilies (*Amaryllis* sp.). During the day they hide in burrows near their food-plant and come out to feed on the leaves at night. Larvae feed on the tubers, eating into the centre.

*Mausoleopsis amabilis*, Schaum. Adults of this Cetoniid are common in the blossoms of various ornamental plants, especially roses.

**Rhynchota.**

*Aspidiotus (Chrysomphalus) aonidum*, L. A common scale-insect on rose stalks.

*Pseudococcus virgatus*, Ckll. Has been recorded from various ornamental creepers, etc.

**Orthoptera.**

*Chrotogonus hemipterus*, Schaum. A very troublesome grasshopper; one experimental field of castor was ruined by its depredations.

## INSECTS INJURIOUS TO STORED PRODUCTS.

In the tropics, where food is abundant throughout the year, insects attacking stored grain are more in evidence than in Europe. Owing to the custom of storing grain in loose receptacles and exposing it in open bins for sale nearly every sample showed evidence of insect attack.

**Coleoptera.**

*Calandra oryzae*, L. This cosmopolitan pest of grain is extremely common in rice, and is also found in maize and sorghum.

*Laemophloeus pusillus*, Schönh. Very abundant in maize.

*Tribolium castaneum*, Hbst. Common in maize and occasionally found in rice.

*Silvanus surinamensis*, L. Abundant in maize.

*Tenebroides mauritanicus*, L. An occasional pest of maize.

*Bruchus chinensis*, L. A serious pest of all beans and pulses. Numbers are always to be found in *Phaseolus mungo* and *Cajanus indicus*.

*Bruchus ornatus*, Fhs. Not so common as *B. chinensis*, but has been recorded from beans.

*Carpophilus humeralis*, F. Very common in maize cobs in the field, generally in those attacked by fungus.

*Cossonus suturalis*, Boh. An occasional pest of stored sweet potatoes.

*Dermestes vulpinus*, F. Abundant in dried fish.

*Latheticus oryzae*, Waterh. An occasional pest of maize.

*Rhizopertha dominica*, F. Occasionally in maize.

*Necrobia rufipes*, de G. Both larvae and adults are abundant in dried copra, feeding on the kernels; the former bore long cylindrical tunnels into the dried copra.

**Lepidoptera.**

*Ephestia cautella*, Wlk. Larvae very common in rice and various flours.

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A young Coconut Palm with stunted leaves badly attacked by *Oryetes*, showing the entry hole of an adult Beetle at the base of a leaf-stalk.





Leaf of Coconut Palm broken off just above the Bore-hole of an *Oryctes*.







An *Oryctes* boring into the heart of a young Coconut Palm.



## ON THE USE OF EXPERIMENTAL PLOTS WHEN STUDYING FOREST INSECTS.

By IVAR TRÄGÅRDH, D.Sc., F.E.S.,

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The problems of how to obtain accurate records of the infestation of injurious insects has during recent years received considerable attention; and when we take into consideration that it is quite as impossible to study the course of an outbreak during its different stages as it is to compare two outbreaks occurring in different localities or at different times, without possessing methods of recording in an accurate way the degree of infestation and injury, it is evident that every effort must be made to solve this difficulty and devise means of obtaining accurate records in these respects.

In the case of the insects injurious to forest trees this need of accurate information is, for various reasons, perhaps still more urgent than in the case of herbivorous insects, but at the same time the problem seems to present fewer difficulties. The necessity for possessing accurate methods of recording the infestation and the injury done is obvious, because the attacks made on the trees by injurious insects often continue for several years, which means that the degree of infestation and the amount of injury done must be continually observed and accurately recorded during several years, if we are to obtain a reliable idea of the course of the outbreak and to be able to predict the probable seriousness of the attack during a succeeding year. It is also, in the case of forest insects, necessary to investigate the consequence of the injury to the health of the trees and to observe the infestation of secondary insects following upon the primary ones, in order to know what measures are to be adopted to prevent the spreading of an outbreak or the deteriorating of the timber if the trees are killed.

But on the other hand, trees undoubtedly present fewer difficulties to such investigations than do herbaceous plants, because, at least in many instances, the degree of infestation may easily be fairly estimated without in the least interfering with the trees or causing any disturbance in the prevailing conditions at the period when the insects have temporarily migrated from the trees and are hibernating in the ground.

When investigating an outbreak of the pine-tree looper (*Bupalus piniarius*, L.), for instance, the degree of infestation is comparatively easy to ascertain by counting the pupae in the ground in May in different parts of the forest; all that is required being a sufficient number of girls or boys to examine the ground thoroughly. The amount of injury done, viz., the degree of defoliation, on the other hand, is more difficult to estimate, especially when the same trees are to be examined during several years, which makes it impossible to fell them and count the number of devoured or half-devoured needles.

During the recent outbreak of *Bupalus piniarius* in Sweden in 1916-1917 the author had occasion to devote some time to the studying of these problems, and in the following paragraphs the method employed will be briefly described.



We find in the literature regarding *Bupalus piniarius* the statement that the trees are able to withstand a defoliation, provided it is not repeated and does not occur early in the autumn. If, on the other hand, the defoliation is repeated during two years in succession the trees are said to be past recovery. As this conclusion was based on observations made chiefly in Germany and as it did not seem safe to assume its applicability in Sweden, investigations on the state of health of pine-trees after a defoliation repeated during two years were carried on in 1917 and 1918.

At Sörby in Södermanland the degree of infestation in May 1917 was found to be 97.8 pupae per square metre, 18 per cent. of which were parasitised. By counting the needles it was found that the average defoliation at the top of the trees was 75%, the injury decreasing gradually downwards, so that in the lower part of the crown about 60% of the needles were intact.

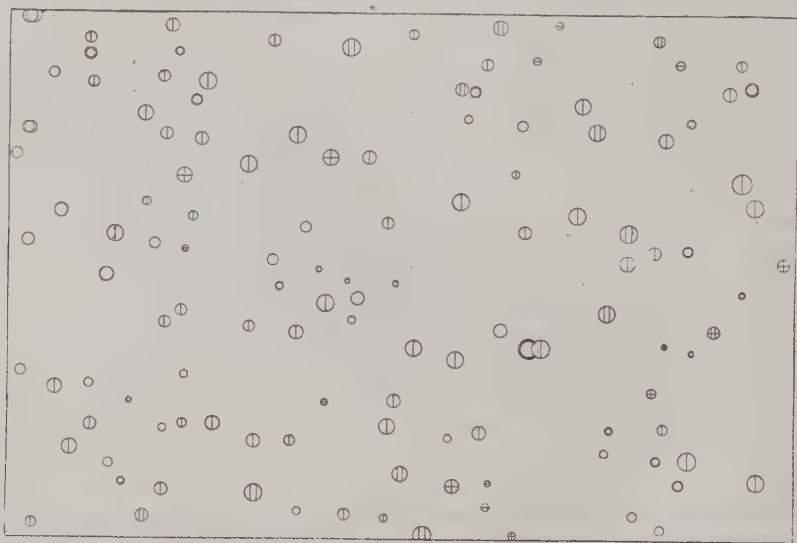


Fig. 1. Map of experimental plot in pine forest attacked by *Bupalus piniarius*, L., at Sörby, Sweden; 0 = felled trees, I = average defoliation, II = severe defoliation, — = attack by the pine beetle.

At the same time an experimental plot was laid out in the part of the forest most seriously injured. In this plot the trees were marked with numbers; their height, diameter at breast height, and the distances between them were measured; and a map was drawn (fig. 1), the scale used for the plot being 1:100 and for the trees 1:400. Further, the degree of defoliation of each tree was recorded, only three degrees being distinguished, viz., no injury, average injury, severe injury. The plot was re-examined in May 1918, when also the degree of infestation was ascertained, the number of pupae being found to have been then reduced to 8.8 per square metre, 60% of which were parasitised.

The examination made in 1918 revealed the fact—as astonishing as it was satisfactory—that in spite of the attacks during the two previous years not a single tree had yet succumbed. In 4% of the trees, however, pine-beetles were breeding

and in 10% they had in vain attempted to enter. The supposition at once presents itself that the primary cause of the attack of the pine-beetle was the defoliation brought about by *Bupalus piniarius*, which had weakened the trees to such an extent as to render them appetising to the beetles. A closer examination of the trees on the experimental plot showed, however, that this cannot be the case in this instance, at least not to any great extent.

According to the estimates made in 1917, 71 of the 126 trees of the plot had an average injury, 14 being severely defoliated and the rest having escaped any visible damage. Only one of the 14 severely injured trees had in the spring of 1918 been attacked by the pine-beetle, and that in vain. Moreover, we notice that one of the trees in which the pine-beetle was breeding had not previously been attacked by *Bupalus*, nor had five other trees into which the beetle had in vain tried to enter been previously injured by the moth. Fig. 2 shows how the attacks of the moth

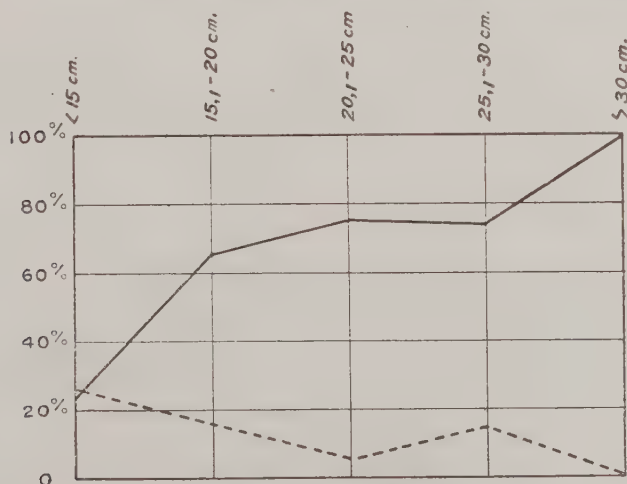


Fig. 2. Diagram showing the distribution of attacks of *Bupalus piniarius* (solid line) and the pine beetle (dotted line) on trees of different dimensions.

and beetle are distributed in trees of different dimensions, from which it is evident how little the attack of the pine-beetle is connected with that of *Bupalus*. We notice that only 24% of the trees measuring less than 15 cm. at breast height have suffered from the moth, whereas all trees measuring more than 30 cm. have been attacked. The pine-beetle, on the other hand has preferred the smaller trees, those exceeding 30 cm. not being attacked at all.

From this it is evident that the two insects, the pine-tree looper and the pine-beetle, work on two different lines, one selecting the largest trees, the other preferring the smaller ones. The investigation has also revealed the fact that during the outbreak in 1916-1917 the forest was able to withstand the defoliation and that the subsequent attack of the pine-beetles was in no way the consequence of the previous defoliation, but would have happened in any case.

It is of course impossible to draw any conclusions from these data as to what is likely to happen during other outbreaks, among other things, because we have no data regarding the parasites of the eggs and the younger larval stages; but if other outbreaks are studied in the same way, it seems likely that we shall by degrees be able to prognosticate after the first year the fate of forests attacked by *Bupalus*.

During such investigations, as well as others when special attention is paid to the influence of the attack on the health of the trees, I venture to think that the use of experimental plots as outlined above will be found very expedient or even indispensable.

# THE CHAETOTAXY OF THE PUPA OF *STEGOMYIA FASCIATA*.

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The pupa of *Stegomyia fasciata* is furnished with 200 setae, 100 on each side, which may be conveniently described according to their situations as follows:—

## Cephalo-thoracic setae,

<i>Post</i> Circum-ocular .. .. .	3
Antero-thoracic .. .. .	4
Dorsal .. .. .	1
Supra-alar .. .. .	1
Postero-thoracic .. .. .	3

## Abdominal setae,

Dorsal (including the lateral setae and the setae on the paddles) .. .. .	61
Ventral .. .. .	27

100 on each side.

The pupa is bilaterally symmetrical, that is, setae occur in similar situations on each side of the body, so that it will suffice to describe the arrangement on one side only. The setae on the two sides of the same pupa, however, often vary as regards their sub-divisions, and similar variations occur between different individuals; as an example, in Table I are shown some of the variations that were found in ten pupae taken at random. An examination of a larger number would have revealed a wider range. As a rule, a seta which is sometimes single, sometimes divided, is longer when single. For example, in one pupa the seta at the posterior angle of

TABLE I.

*Cephalo-thoracic Setae, showing the Variations found in ten Pupae.*

Seta.		1	2	3	4	5	6	7	8	9	10
<i>Post</i> Circum-ocular, Superior .. .. .	Superior	1	1	2	1	1	1	1	1	1	1
<i>Post</i> Circum-ocular, <i>Median</i> Posterior .. .. .	Posterior	2	2	1	2	1	1	2	2	2	2
<i>Post</i> Circum-ocular, Inferior .. .. .	Inferior	1	1	3	1	1	1	1	1	1	1
<i>Lower</i> Antero-thoracic, Anterior .. .. .	Anterior	3	2	2	3	3	2	2	2	3	3
<i>Lower</i> Antero-thoracic, <i>Upper anterior</i> Superior .. .. .	Superior	1	2	2	1	1	1	2	2	3	3
<i>Lower</i> Antero-thoracic, Antero-inferior .. .. .	Antero-inferior	1	1	1	1	1	1	1	1	1	1
<i>Lower</i> Antero-thoracic, <i>Aciculate</i> x Posterior-inferior .. .. .	Posterior-inferior	1	1	2	1	2	1	2	2	2	2
Dorsal .. .. .		1	1	1	1	1	1	1	1	1	1
Supra-alar .. .. .		2	2	2	2	2	2	2	2	2	2
Postero-thoracic, Internal .. .. .	Internal	1	1	1	1	1	1	1	1	1	1
Postero-thoracic, Median .. .. .	Median	1	1	1	1	1	1	1	1	1	1
Postero-thoracic, External .. .. .	External	2	2	1	1	1	1	2	2	1	1



the seventh segment was single on the right side, double on the left; the former measuring  $266\mu$ , and the latter only  $159\mu$  in length. This fact is not specifically mentioned in the descriptions which follow, but should be understood.

It has been stated that "As the pupa increases in age additional hairs are developed." In *Stegomyia fasciata* this is not the case, the pupa immediately after it has shaken itself free from the larval skin having exactly the same number of setae as pupae one or two days old, and as pelts left behind after the emergence of the adult mosquitos. The setae on male and female pupae are also identical.

The description which follows is based on the comparison, seta by seta, of ten specimens of the pupa of *Stegomyia fasciata*.

### **Cephalo-thoracic Setae.**

The setae on the cephalo-thorax are few in number, and relatively inconspicuous. There are altogether twenty-four, namely twelve on each side of the body.

#### **Post-ocular setae.** (fig. 1).

These setae are situated close to the posterior margin of the eye, and are sometimes difficult to see because, being directed forwards and outwards, they are apt to be obscured by the dark ocular pigment behind them. In a pelt they are also difficult to find, as they become displaced when the mosquito emerges. They are best seen in pupae which have been macerated in caustic potash. There are three post-ocular setae, namely:—

*Superior seta* (fig. 1, <sup>1</sup>). A delicate seta of moderate length situated in the angle formed between the upper posterior margin of the eye and the lower border of the antenna as it sweeps backwards; usually single, sometimes double.

*Median seta* (fig. 1, <sup>2</sup>). A small delicate seta situated just behind the eye near its lower margin; usually double, sometimes single.

*Inferior seta* (fig. 1, <sup>3</sup>). A delicate seta of moderate length situated a little below the median seta and at about the level of the posterior margin of the eye; usually single, but in one specimen triple on one side.

#### **Antero-thoracic setae** (fig. 1).

These setae are situated at the anterior margin of the thorax, or rather in the triangular area between the anterior margin of the thorax and the upper border of the antenna as it sweeps backwards. They are directed forwards, upwards, and outwards. There are four antero-thoracic setae, namely:—

*Lower anterior seta* (fig. 1, <sup>4</sup>). A delicate seta of moderate length situated a little above the antenna and a little behind the anterior margin of the cephalo-thorax; double or triple.

*Upper anterior seta* (fig. 1, <sup>5</sup>). A delicate seta of moderate length situated above and slightly posterior to the lower anterior seta; single, double, or sometimes triple.

*Lower posterior seta* (fig. 1, <sup>6</sup>). A stouter and longer seta than any of the preceding, situated just above the eye close to the upper margin of the antenna as it sweeps backwards; single.

*Upper posterior seta* (fig. 1, <sup>7</sup>). A seta of moderate length and strength situated close to, and immediately behind the lower posterior seta; generally double, sometimes single.

**Dorsal seta** (figs. 1, <sup>8</sup>; 2, <sup>6</sup>).

This seta is situated on the thorax a little posterior and internal to the respiratory trumpet, and is directed upwards. It is small and delicate; usually double, but sometimes single or triple.

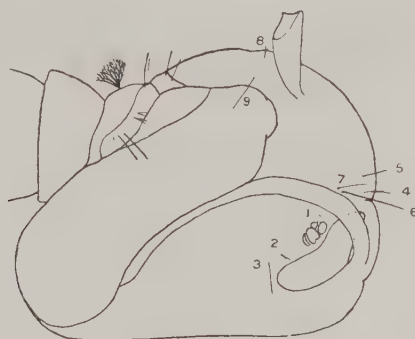


Fig. 1. Cephalo-thorax of pupa of *Stegomyia fasciata*, lateral view.

- 1-3. Post-ocular setae: 1, superior; 2, median; 3, inferior.  
 4-7. Antero-thoracic setae: 4, lower anterior; 5, upper anterior; 6, lower posterior; 7, upper posterior.  
 8. Dorsal seta.  
 9. Supra-alar seta.

**Supra-alar seta** (figs. 1, <sup>9</sup>; 2, <sup>7</sup>).

This seta is situated on the thorax above the root of the wing, and is directed outwards and forwards. It is rather long and slender; single.

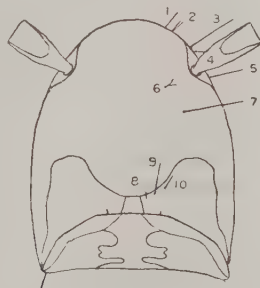


Fig. 2. Cephalo-thorax of pupa of *Stegomyia fasciata*; dorsal view.

- 1-4. The ends of the antero-thoracic setae: 1, upper anterior; 2, lower anterior; 3, lower posterior; 4, upper posterior.  
 5. The end of the superior post-ocular seta.  
 6. Dorsal seta.  
 7. Supra-alar seta.  
 8-10. Postero-thoracic setae: 8, internal; 9, median; 10, external.

**Postero-thoracic setae** (fig. 2).

The posterior part of the cephalo-thorax is readily detached as a separate piece which is concave both anteriorly, where it fits on to the rest of the cephalo-thorax. and posteriorly, where it joins the first abdominal segment. It consists of two lateral triangular plates connected by a narrow central bridge. The bridge is composed of a small quadrilateral area in the middle, and on each side a short prolongation, from the anterior margin of which arise the postero-thoracic setae. These setae are directed forwards and outwards. There are three postero-thoracic setae, namely :—

*Internal seta* (fig. 2, <sup>8</sup>). A seta of moderate size and strength situated close to the outer margin of the quadrilateral area ; usually double, sometimes single or triple.

*Median seta* (fig. 2, <sup>9</sup>). A stouter and longer seta situated a little external to the internal seta ; single.

*External seta* (fig. 2, <sup>10</sup>). A seta of moderate size and strength situated a little external to the median seta ; single or double.

**Abdominal Setae.**

The majority of the setae of the pupa are attached to the abdominal segments : those on the ventral aspect being for the most part small and inconspicuous, those on the dorsal and lateral aspects being more highly developed, and including the setae of greatest systematic importance.

**Dorsal abdominal setae** (fig. 3).

The dorsal abdominal setae are numerous, and are mostly situated near the posterior margins of the segments. With them may be ranked the lateral setae, which are of importance because they provide convenient means for specific determinations, and the setae on the ends of the paddles. With the exception of the setae on the first segment all the abdominal setae are directed backwards.

Certain of the dorsal abdominal setae fall naturally into series, and it will be convenient to describe all the setae in relation to them. The following series can readily be recognised :—

1. The setae composing the *lateral row* (fig. 3, A). These are especially well developed setae situated at, or slightly anterior and internal to, the posterior angles of the segments. On the most anterior segments they are slightly ventral.

2. A series of delicate setae situated close by and internal to the setae of the lateral row (fig. 3, A').

3. The setae composing the *sub-median row* (fig. 3, C). These setae are situated near the posterior margin of the segments at a point about half-way between the middle line and the posterior angle.

4. A series of setae situated near by and anterior to the setae of the sub-median row (fig. 3, C', C'').

5. The setae composing the *sub-lateral row* (fig. 3, B). These setae are situated near the posterior margins of the segments at a point about half-way between the sub-median row and the posterior angle.

6. A series of setae situated near by and anterior to the setae of the sub-lateral row (fig. 3, B').

7. A series of very minute setae, the *anterior dorso-central setae* (fig. 3, D), situated near the anterior margins of the segments almost in line with the setae of the sub-median row.

The dorsal abdominal setae may now be described as they occur on each segment making use of the abbreviations A, A', B, B', C, C', C'', and D, as defined above.

#### SEGMENT I.

There are eight setae on each side of the first segment; unlike those on the more posterior segments they are not directed backwards.

*Dendritic tuft.* In the middle of the segment, and at a short distance from the middle line, is a large seta developed into a dendritic tuft, which arises from a delicate membrane and is directed upwards. It has a triangular basal portion

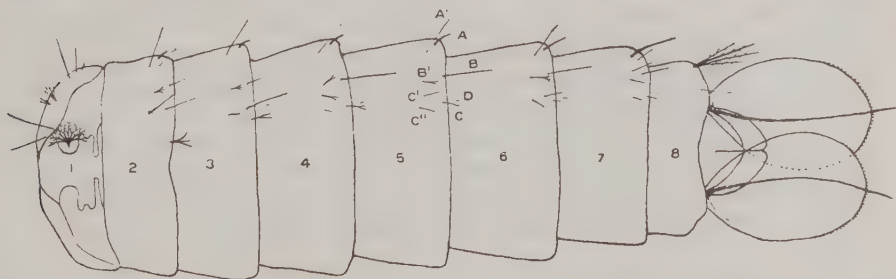


Fig. 3. Abdomen of pupa of *Stegomyia fasciata*, dorsal view; for explanation see text.

which gives rise to a number of stout primary branches, seven to sixteen in number, which in turn divide and subdivide repeatedly. This seta may correspond to C on the more distal segments.

*Antero-internal seta.* A long, stout seta situated immediately anterior to the dendritic tuft, and directed forwards; single. This seta may correspond to C'' on the more distal segments.

*Antero-external seta.* A stout seta of greater length situated close to the antero-internal seta, but a little external and posterior to it; directed forwards and outwards; usually single, sometimes double. This seta may correspond to C' on the more distal segments.

*Medio-internal seta.* A small tuft of two to four hairs situated near the anterior margin of the segment about half-way between the antero-internal seta and the lateral border; directed forwards and outwards. This seta may correspond to B' on the more distal segments.

*Medio-external seta.* A tuft of two to five hairs, rather longer than the medio-internal tuft and situated close to it but slightly posterior and external; directed forwards and outwards. This seta may correspond to B on the more distal segments.

*Posterior-internal seta.* At the point where the lateral border of the segment begins to curve inwards there is a group of three setae: the innermost of these is



the postero-internal seta. It is a rather long delicate seta, directed outwards or forwards and outwards; usually single, sometimes double. This seta may correspond to A" on the second segment.

*Postero-external seta.* A rather long seta situated close by and external to the postero-internal seta, directed outwards or forwards and outwards; usually single, sometimes double. This seta may correspond to A' on the second segment.

*Lateral seta.* A small seta external to the postero-external seta and situated just posterior to the angle made by the border of the segment curving inwards; directed outwards; single. This seta seems to correspond to A on the more distal segments.

## SEGMENT II.

A—short, fairly stout but not very highly chitinised; single. A' and A"—there are two long, delicate setae situated close by and internal to the lateral seta, the one (A") slightly anterior to the other (A'); both usually single or double. B—delicate seta of moderate length; single, double, or triple. B'—small delicate tuft of two to five hairs situated a little anterior and internal to B. C'—a rather long seta situated internally to B and B', and near the posterior margin of the segment; single, occasionally double. C"—a seta of moderate length situated at about the same level as B', but internal to it, and slightly either internal or external to C'; single. Nearer the middle line than C', and near the posterior margin of the segment, is a seta of moderate size which may represent C displaced inwards; usually double or triple, occasionally single. D—a minute seta.

## SEGMENT III.

A—short and stout, rather longer and stronger than on the second segment; single. A'—a long delicate seta situated anterior and internal to A; single or occasionally double. B—seta of moderate length; single, double, or occasionally triple. B'—small tuft of two to four hairs or a single seta, anterior and internal to B. C—a seta of moderate size situated near the posterior margin of the segment a little internal to the line of the sub-median row; usually single or double, but occasionally with as many as five branches. C'—a rather long seta situated at some distance externally to C, and anterior to it; single or double. C"—a small seta, relatively stout, placed more anteriorly but less exteriorly than C'; single. D—a minute seta.

## SEGMENT IV.

A—short and stout, rather longer than on the third segment; single. A'—a long delicate seta situated anterior and internal to A; usually single, occasionally double or triple. B—a long seta reaching half-way or further across the fifth segment; single. B'—a small seta anterior and internal to B; single, double, or triple. C—a delicate seta of moderate length; single or double. C'—a seta of moderate length external and anterior to C; double or triple. C"—a small rather stouter seta internal and anterior to C; single. D—a minute seta.

## SEGMENT V.

A—stout, longer than on the fourth segment; single. A'—a long delicate seta anterior and internal to A; single, occasionally double. B—a long seta reaching

about half-way across the sixth segment ; single, occasionally double. B'—a small seta anterior and a little internal to B ; usually double, sometimes single or triple. C— a moderately long delicate seta ; single or double. C'— a moderately long delicate seta external and anterior to C ; single or double. C''— a rather short, relatively stout seta internal and anterior to C ; single, occasionally double. D— a minute seta.

#### SEGMENT VI.

A— stout, longer than on the fifth segment ; single, end occasionally forked. A'— a long delicate seta anterior and internal to A ; single, occasionally double. B— a long seta reaching nearly half-way across the seventh segment ; single. B'— a delicate seta of moderate length anterior and a little internal to B ; usually double, occasionally single. C— a rather small delicate seta ; single or double. C'— a seta of moderate length external and a little anterior to C ; single, occasionally double. C''— a small seta, rather stouter, anterior and internal to C' ; single. D— a minute seta.

#### SEGMENT VII.

A— a long strong seta, sometimes pubescent ; single or double. A'— a delicate seta of moderate length close by and internal and posterior to A ; single or double, occasionally triple. B— a rather long seta, single. B'— a rather long delicate seta external and anterior to B ; single. B''— a smaller delicate seta internal and anterior to B ; single, occasionally double ; this seta probably corresponds to C' on the more anterior segments. C— a rather small delicate seta ; single. C''— a small seta, rather stouter, anterior to C ; single ; this seta probably corresponds to C'' on the more anterior segments. D— a minute seta.

#### SEGMENT VIII.

A— a well developed tuft of two to five, usually four, strong hairs, sub-plumose and sometimes branched. D— a minute seta. There is one other seta, P, on this segment, situated near by and external to the root of the paddle ; it is rather long, slender, and single. At the distal end of the midrib of the paddle there is a moderately long strong seta (P) ; single.

#### SEGMENT IX.

No setae.

A typical segment may be regarded as having the following setae : a lateral seta with a seta a little internal to it ; a seta belonging to the sub-lateral row with a seta a little anterior to it ; a seta belonging to the sub-median row with two setae, the one internal to the other, a little anterior to it ; and a minute anterior dorso-central seta.

#### Ventral Abdominal Setae (fig. 4).

The ventral abdominal setae are relatively inconspicuous. They are directed backwards, and most of them are situated near the posterior margins of the segments. Some of them are arranged in series, and it will be convenient to describe them before enumerating the setae found on the different segments. The following series can be recognised :—

1.—A series of setae, the *medio-lateral setae* (E), situated a little posterior to the middle points of the segments a short distance internal to their lateral borders.

2.—A series of setae, the *postero-lateral setae* (D), situated near the posterior margins of the segments a little internal to the posterior angles.

3.—A series of setae, the *inner ventral setae* (B), situated near the posterior margins of the segments at points about half-way between the middle line and the posterior angles.

4.—A series of setae, the *outer ventral setae* (C), situated near the posterior margins of the segments between the inner ventral setae and the postero-lateral setae.

5.—A series of minute setae, the *anterior ventro-central setae* (A), situated close to the anterior margins of the segments and very near the middle line of the abdomen. These setae, owing to their size and position, are often impossible to see.

The ventral abdominal setae may now be described as they occur on each segment, making use of the abbreviations, E, D, C, B, and A, as defined above.

#### SEGMENT I.

No setae.

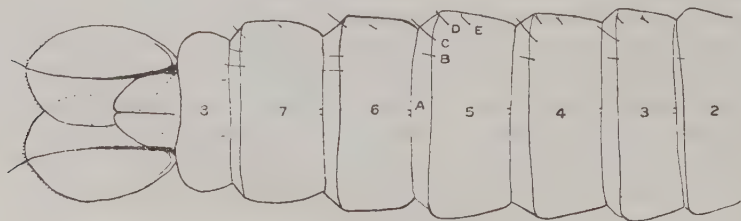


Fig. 4. Abdomen of pupa of *Stegomyia fasciata*, ventral view; for explanation see text.

#### SEGMENT II.

The only seta detected on this segment is a delicate single seta of moderate length situated in a position corresponding to B. This seta is inconstant; that is to say, in some pupae it was absent, and no socket could be found from which it might have been detached.

#### SEGMENT III.

E—small, delicate; usually double or triple, occasionally single. D—a short tuft of two to four hairs, sometimes branched. C—a delicate seta of moderate length; single. B—a small, relatively stout, seta; single. A—a minute seta.

#### SEGMENT IV.

E—a small delicate seta; usually double, sometimes single or triple. D—a small tuft of two or three hairs, sometimes a single seta. C—a long delicate seta; single. B—a short, relatively stout seta; single. A—a minute seta.

#### SEGMENT V.

E—a small delicate seta; usually double, sometimes single or triple. D—a small tuft of two to four hairs, or a single seta. C—a long delicate seta, rather longer than on the fourth segment; single. B—a short, relatively stout seta; single, sometimes forked at the end. A—a minute seta.

## SEGMENT VI.

E— a small delicate seta ; single, double, or triple. D— a delicate seta ; usually single, sometimes double. C— not represented. B— a small stoutish seta ; single. A— a minute seta. A little internal to B there is a delicate single seta of moderate length (B').

## SEGMENT VII.

E— a small delicate seta ; single, or more frequently double or triple. D— a delicate seta ; single. C— not represented. B— a small stoutish seta ; single. B'— a delicate single seta, similar to that on the sixth segment, a little internal to B. A— a minute seta. The correlation of the setae near the posterior margin of this segment and the sixth is not quite clear, and the difficulty is increased on this segment because, owing to the reduced width, the relative positions are misleading. The interpretation suggested is based on the facts that the seta D is in line with the corresponding setae on the more anterior segments, and the seta B is in line with, and similar in appearance to the seta B on the other segments.

## SEGMENT VIII.

The only seta found on this segment is a very small single seta situated close to the anterior margin of the segment at a point nearly two-thirds of the distance from the lateral border to the middle line. This seta may represent A, which appears to be absent, but if so it is displaced outwards and a little backwards.

## SEGMENT IX.

No setae.

A typical segment may be regarded as having the following setae : a medio-lateral seta, a postero-lateral seta, an outer ventral seta, an inner ventral seta, and a minute anterior ventro-central seta.





## A NEW HISPID BEETLE INJURIOUS TO THE OIL PALM IN THE GOLD COAST.

By S. MAULIK,

*Professor of Zoology in the University of Calcutta.*

Through the courtesy of Dr. G. A. K. Marshall I have had the opportunity of examining specimens of a beetle belonging to the subfamily HISPINAE of the CHRYSOMELIDAE, which is reported to be injurious to oil palms (*Elaeis guineensis*, Jacq.) in the Gold Coast. Concerning this insect Mr. W. H. Patterson, Government Entomologist in the Gold Coast, writes as follows:—"The beetle has suddenly become a pest, being reported as having destroyed all the expanded foliage of many thousand oil palms in one district. A similar epidemic occurred in 1909, but entirely disappeared during the following rainy season, since which time the beetle has been very rare." From this it would appear that the extent of damage is considerable when the insect becomes numerous. Although Mr. Patterson does not indicate the nature of the damage there is no doubt that the larvae mine into the young shoots and the adults defoliate the young leaves. In a recent work (Hispinæ and Cassidinae, Fauna of Brit. Ind., London 1919, pp. 10-18) I have reviewed all the Hispid pests of plants useful to man. Only two African Hispids have hitherto been noted as harmful, and these attack maize in East Africa.

Only four species of the genus *Coelaenomenodera*, to which the present insect belongs, are known from the continent of Africa, viz., *speciosa*, Gestro, *signifera*, Gestro, *thomsoni*, Gestro, and *costulata*, Kolbe, the rest of the species, about 28 in number, are from Madagascar.

The present insect differs from *speciosa* by the shape of the prothoracic lobe; from *signifera* by its size, though the lobe is similar; from *thomsoni* by the fact that it has the basal six joints yellow to reddish black, a character which also separates it from *signifera*; and from *costulata* by the shape of the prothoracic lobe and the fact that the antennae (except the first joint) and the tarsi are black. It is necessary therefore to describe the present species as a new one.

***Coelaenomenodera elaeidis*, sp. nov. (fig. 1).**

Body oblong, slightly broadened behind. Colour pale yellow; elytra reddish, except the basal and apical areas, this reddish colour disappearing when the specimens are preserved in alcohol; mandibles, eyes, and the five apical joints of the antennae black; the basal joints gradually become red-brown mixed with black from the yellow of the basal joint to the almost black sixth joint. The frontal lobe of the prothorax is elongate anteriorly and projects in front, concealing the forehead.

*Head*: the interantennal space is slightly raised, and the eyes strongly convex. The antennae pass a little beyond the base of the prothorax and are sparsely covered with whitish hairs, the six basal joints being smooth and shining and the five apical thickened; the first joint is small, the second longer, the third, fourth and fifth equal to each other, and the sixth is intermediate between the thickened apical

joints and more slender basal ones. *Prothorax* shining, longer than broad, slightly narrower at the base than the base of the elytra; the anterior angles are ill-defined, owing to the frontal lobe, the posterior acute and produced; the sides are undulated. The upper surface is convex; at the base in front of the scutellum is a deep depression, and there are two others at each side, a small one just below the frontal lobe and a larger one posterior to it; in these depressions are a few punctures. The frontal lobe is semi-elliptical in shape, hollowed, with a median longitudinal ridge; the front border of the lobe varies, being sometimes rounded and sometimes more pointed; its surface is semi-transparent, with a few indistinct large punctures. Behind the lobe the surface is uneven, being slightly depressed in the middle and sloping posteriorly. *Scutellum* small, inconspicuous, deeply sunk in a hollow. *Elytra* punctate-striate, each with three costae terminating at the point where the surface slopes down towards the apex, the lateral margins being slightly expanded. Between

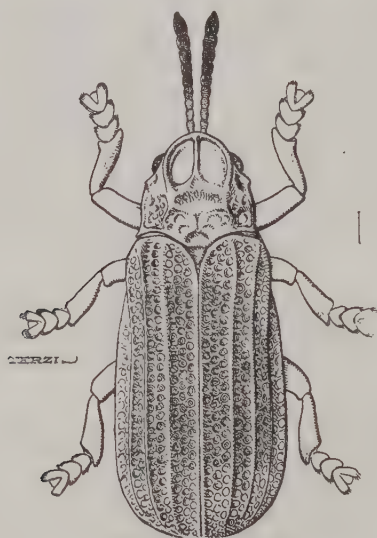


Fig. 1. *Ooelaznomenodera elaeidis*,  
Maulik, sp. n.

the suture and the first costa there are three rows of punctures, between the first and second costae two, between the second and third two, and between the third and the lateral margin three; the punctures are coarse and deep. *Underside* uniformly pale yellow, less shining than the upper side. The tibiae are short; the mid and hind tarsi are almost as long as the tibiae and broader at the apex than at the base, so that the basal joints are smaller than the following ones; the front tarsi are as broad at the base as at the apex, so that all the joints are equal in breadth. The venter is slightly hairy.

*Length*, 4.75–5.75 mm.

*Type* in the British Museum.

Described from 11 examples.

*Larva* (fig. 2). The full-fed larva is flattish, creamy white, and measures about five millimeters in length (dried specimen mounted on card). The abdomen has ten segments, including the last, on the underside of which the anus is situated; the thorax is three-segmented, so that with the head the larva is composed of 14 segments. There are altogether nine pairs of spiracles: one pair on the mesothorax, and a pair on each of the first eight abdominal segments, each spiracle being placed on the side of the dorsal surface, except that on the mesothorax, which is ventral. The prothoracic segment is considerably expanded laterally, the expansions being rounded, and is deeply emarginate in the middle for the reception of the head. The

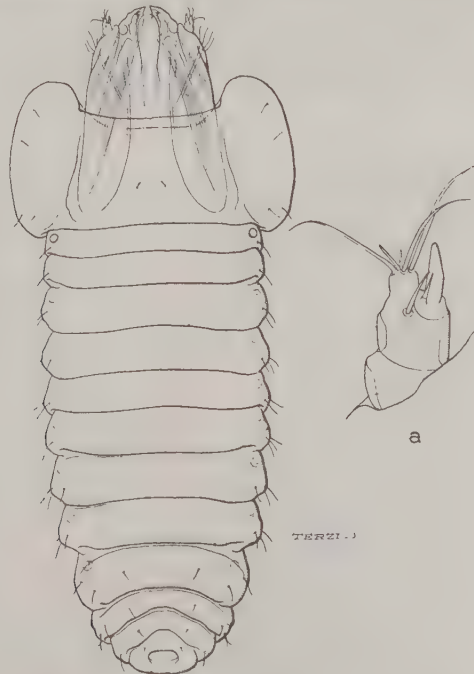


Fig. 2. Larva of *C. claeidis* (ventral view);  
a, antenna.

meso- and metathorax are not expanded laterally. Each abdominal segment has a slight rounded expansion on each side bearing two fine hairs at the edge in the middle, which are homologous with the well developed projections from the sides of the segments of other Hispid larvae. The larva has no legs.

#### *Morphology of the Larval Mouth.*

The head is supported in the prothorax by means of two large elongate-oval structures with strongly chitinised edges and chitinised supports in the middle, which are inclined to each other at an angle, meeting anteriorly at the mandibles, and having nearly half their length inside the prothorax. Compared with the size of these structures, the mandibles, which form their apical part, are minute. The



buccal cavity is formed by an upper membranous structure (epipharynx), supported by two chitinous pieces outwardly bent (fig. 3, B), a lower lip (labium) (fig. 3, A, l) and the mandibles. The upper structure has numerous papilliform hairs directed inwardly and posteriorly. These are probably connected with the pharyngeal muscles and control their action according to the stimuli received from the food particles. The condyles of the mandibles (fig. 3, A, *md.*) are controlled by two bands of muscles (fig. 3, A, *ms.*), and the apices of the mandibles are pointed, the inner border being uneven without any teeth. The labium is a membranous structure with the apex broadly rounded. No labial palpi are observable in the present preparation. A pair of maxillae is present, situated ventrally to the mandibles, each consisting of a base and the main lobe; on the inner border of this lobe are numerous hair-like structures. Although in the preparation before me I cannot see the maxillary palpi, it is possible that they are present. An antenna is situated

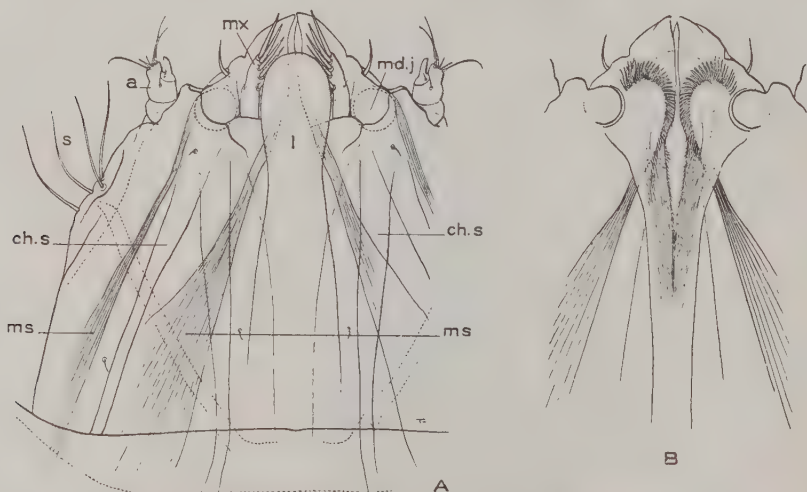


Fig. 3. Larva of *C. elaeidis*, mouth-parts; *md.j*, mandibular joint; *mx*, maxilla; *ch.s*, chitinous supports; *ms*, muscles controlling the movement of the mandibles; *l*, labium; *s*, setae; B, roof of the mouth.

on each side of the head a little posterior to the mandibular joint; it is two-jointed, with a simple lobe at the apex of the second joint and another stouter one bearing several papillae (fig. 2, *a*).

The foregoing observations are taken from preparations made from two larvae, one full fed and the other younger. They were cleared in potash and washed and put in 90 per cent. alcohol slightly coloured with Congo red for about 12 hours; the chitin was stained well, showing good differentiation. With more material the structures may be made out with more precision and in greater detail than I have been able to do at present. The figure of the larva has been drawn from a balsam preparation; in clearing in potash the specimens get stretched to a certain extent. In drawing the figures of the mouth-parts of the larva the artist was aided by three photomicrographs taken by myself.

## OBSERVATIONS ON SCALE-INSECTS (COCCIDAE).—VI.

By ROBERT NEWSTEAD, F.R.S.,

*The School of Tropical Medicine, the University, Liverpool.*

(PLATE XVI.)

**Glypeococcus**, gen. nov.

*Female.* Dorsum nude and densely chitinated. Marsupium occupying practically the whole of the interior. Venter (sternites) remaining attached to the food-plant. Legs and antennae present. Cephalic margin with a strongly developed clypeus, lying prone over the mentum. Abdominal stigmata present.

*Larva* of the *Icerya* type, and with several pairs of abdominal stigmata.

Type, *C. hempeli*, Ckll.

**Glypeococcus hempeli**, Ckll.

*Icerya* (*Crypticerya*) *hempeli*, Ckll., Can. Ent. xxxi, p. 43 (1899).

*Crypticerya hempeli*, Hemp., Rev. Mus. Paul., iv, p. 376 (1900).

*Female adult* (Pl. xvi, fig. 1). Sphaeroid and hollow at gestation, the marsupium filling practically the whole of the interior. Integument densely chitinated, faintly ribbed and polished: very dark plum-coloured, with a delicate "bloom-like" secretion, the segmentation of the dorsum indicated by faint blackish interrupted lines. Venter



Fig. 1. *Glypeococcus hempeli*, Ckll., ♀; a, the relative position of the various appendages on the anterior portion of the venter: an, antenna; cl, clypeus; m.sh, membranous sheath enclosing the buccal filaments; b, antenna of larva; c, tarsus of larva; d, gland-pores and hairs on venter of ♀; e, dorsal spines of larva; f, gland-pores of larva.

membranous, resting on a thin layer of hard resin-like secretion, segmentation distinct. Mentum biarticulate, the "filaments" enclosed in a membranous sheath (m.sh. in (C605)

fig 1, *a*), the latter lying obliquely to one side of the median line in mounted preparations. Clypeus (fig. 1, *a*, *cl.*) strongly produced, densely hairy and *completely overlying the mentum*. Antennae, legs and thoracic stigmata lying in very deep depressions. Ventrally the margins and the whole of the thoracic area, together with the terminal abdominal segment, densely hairy; the hairs (fig. 1, *d*) distinctly knobbed at the tips. Antennae (fig. 1, *a*, *an*) robust, of 8-9 strongly chitinised segments. Legs (fig. 1, *a*) robust, and strongly chitinised; claw simple. Abdominal stigmata small and apparently in six pairs. Thoracic stigmata large; the gland-pores multilocular, the cylindrical ducts long and apparently truncate proximally. Dermal gland-pores (fig. 1, *f*) large and with a deep cylindrical rim; they are irregularly disposed on the venter and for a short distance also beyond the margin; the dorsum rather thickly studded with minute pores surrounded by dark granular bodies. Anus large and roughly circular in the outline formed by the dense chitinous walls of the body; no other exact details observed, but portions of a ruptured membranous cuticle project into the lumen, suggesting that the true structure is wanting. Diameter, 6.5-9mm.; antennae, 0.6 mm. long.

*Larva.* Form elongate. Antennae (fig. 1, *b*) clavate, of six segments; 2nd, 4th, and 6th longest; 3rd and 5th very short and subequal; all the segments with fine slender hairs, the longer ones less than the length of the terminal segment; terminal segment with several slender spinose hairs at the tip; in the clear membrane which connects the 2nd and 3rd segments is a relatively very large chitinous ring with a granular centre; as no hair or spine has been seen attached to this organ it is suggested that it may be a sensorium or gland-pore; three similar structures also occur on the coxae. Legs long and slender; claw (fig. 1, *c*) with a minute, subapical denticle. Dorsal gland-pores with a broad quoit-like rim and a very short cylindrical duct, the whole structure when seen in profile reminding one of a very short-stemmed agaric or broad-flanged stopper to a glass jar; these are arranged more or less in transverse rows. The terminal segments of the abdomen, more especially in the region of the anus, with a group of large spines, packed very closely together in the median area. Terminal abdominal bristles in five pairs; these are of great length, or slightly longer than the antennae. The chitinised hind gut with its flange-like papillae very distinct. Abdomen with at least six pairs of stigmata; the external opening minute and membranous; the atrium long, gradually narrowed distally, strongly ribbed transversely or irregularly moniliform, and the proximal portion with a deep wide cleft; the connective tube slender, chitinised, and bifurcated, each branch having well-formed taenidia; length of the atrium about twice the diameter of the large quoit-like gland-pores.

BRAZIL: San Paulo; on the spiny branches of an unknown tree or shrub (*mimosa* ?), 1906. (In a small collection of Brazilian Coccidae purchased from Mr. O. E. Janson; no other data).

The determination of the species is based upon an examination of a specimen (ex coll. T. D. A. Cockerell) kindly supplied by Mr. E. E. Green, to whom I express my thanks, as in the absence of his material I should most certainly have given this insect a new specific name.

I have described the morphological characters in some detail as hitherto the true characteristics seem to have been almost entirely overlooked. The presence of a

strongly developed clypeus in this Coccid it is unique, and is probably homologous with that of certain members of the FULGORIDEA belonging to the genus *Cirius* and other allied forms.

***Aspidoproctus gowdeyi*, sp. nov.**

*Female adult.* Completely covered dorsally with a thick and densely felted layer of dusky white and pale yellow wax; the wax more or less divided into segments corresponding to the segmentation of the body. Venter pale castaneous, slightly mealy and in parts covered with white woolly filaments. Legs pitchy red. Marsupium well developed, the secretory operculum wanting, but apparently broken away.

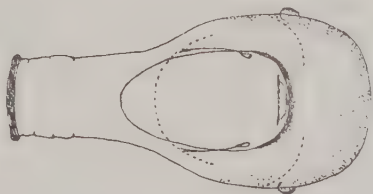


Fig. 2. *Aspidoproctus gowdeyi*, Newst., sp. n.,  
♂ genital armature.

*Male.* In dry specimens the body is uniformly black or piceous. Wings very dark smoky brown or blackish; costa black, subcostal vein dull crimson; forked pseudo-vein dull white and very conspicuous. Halteres with 4-5 strongly hooked bristles. Body mealy. On maceration in KOH the softer parts of the integument change to dull crimson; the sclerites and also the legs and antennae, piceous. The single pair of central processes well developed; terminal bristles varying in length and thickness, the longest about four times the length of the process. Genital armature (fig. 2) shaped somewhat like a flask or ampulla in miniature; the proximal portion broadest; near the centre of the dilated proximal portion is a shallow saucer-shaped appendage suspended to the walls of a large, ovate, chitinous ring; distal portion cylindrical and densely chitinised. Intromittent organ not observed.

UGANDA: Kampala, on plumbago and rose, 15.x.1918 (*C. C. Gowdey*).

The males hatched apparently during transit through the post and were rather badly crumpled and otherwise injured.

***Walkeriana digitifrons*, sp. nov.**

*Female, adult* (Plate xvi, fig. 3). Stationary. Somewhat pyriform, narrowest in front; highly convex and sloping gradually towards the cephalic margin. Dorsum more or less covered with an easily deciduous layer of white or pale buff-white, granular wax; margin with relatively robust, coalescing plates of white wax, which, when perfect, are distinctly laminated transversely; cephalic margin with a short stout, centrally placed, cylindrical process. Integument very hard, dark castaneous or piceous; margin, when denuded, with a series of large blunt tooth-like projections or tubercles, arranged rather widely apart; dorsum with 3-4 bilateral rows of gland pits, in which the granular wax generally remains more or less intact; abdominal



segmentation distinct. Venter hollow, but filled with loose white flocculent material. in which the eggs are laid and the larvae subsequently hatch. Vaginal orifice transversely linear, and without a secretory operculum or an invaginated marsupium. The integument of the dorsum, after long maceration in KOH, becomes pale brown in colour; but partly retains its hard and somewhat brittle nature. Antennae with 10-11 segments; 4th segment the shortest, but its articulation with the 5th is often incomplete, though the constriction between these segments is well marked and relatively deep. Eyes in the form of a truncated cone. Legs rather sparsely hirsute, but normal in shape. Compound gland-pores of the dorsal pits relatively large, rather narrowly ovate, and collectively forming a rather coarse and irregular reticulation. Dorsal gland-pores of the usual multilocular type; they are fairly numerous and more or less evenly distributed; those on the marginal tubercles are surrounded by a radial and somewhat petaloid pattern, due apparently to the thickening of the integument. Ventral gland-pores similar to those of the dorsum, but slightly larger and with an ovate central pore; they are thickly packed together at the margins and also on the marginal tubercles. Anus surrounded by a broad concentric band of dark chitin, which is thickly studded with simple, more or less circular gland-pores. Fine slender hairs are scattered over both sides of the body; marginal hairs also slender, but longer than those on other parts of the body. Length, inclusive of the finger-like process on the cephalic margin, 6-9 mm.

*Larva.* This is of the usual form. Five of the long hairs on the terminal segment of the antennae equalling the length of the body. Sides of the abdomen with numerous long fine hairs; anal hairs or bristles apparently in three pairs, of which the central pair are much the more slender and shorter; outer pairs (2nd and 3rd) relatively stout and longer than the body.

UGANDA: Damba Isl., Sesse Islands, Lake Victoria; on *Baikea eminii*, 8.x.1912 (C. C. Gowdey).

### ***Pseudococcus inquilinus*, sp. nov.**

*Female, adult.* External covering and lateral appendages destroyed by the medium in which the specimens were preserved. Form, when denuded, similar to that of *P. longispinus*, Targ. With 16-17 pairs of cerarii; anal pair with two, the others with from 4 to 7 sharply conical spines. Lateral cerarii (fig. 3, c) with 2-3 auxiliary setae and numerous, obtusely triangular pores rather closely grouped together near the cerarii, but scattered and merging into the body-pores beyond. Anal lobe cerarii (fig. 3, a) surrounded by a small circular chitinised area; ventral surface of each lobe (fig. 3, b) with a broad and somewhat rectangular chitinised area. Anal ring well formed; setae (fig. 3, e) a very little shorter than the anal lobe setae. Dorsal body setae (fig. 3, d) numerous, slenderly spinose, with, in many instances, flagellate tips. Obtusely triangular pores very numerous, intermingled with larger simple pores; and on the last few segments of the abdomen a few multilocular pores; tubular ducts very short and scanty (?) the rims of which are chitinised. Dorsal osteoles large, in two pairs. Legs relatively stout.

The young adult female resembles the old adult, but has the gland-pores more closely packed together.

BRITISH GUIANA: "Cattle Trail Survey," on an unknown plant; "the insects enclosed by ants (*Acromyrmex* sp.) in small paper nests," 1919 (*A. A. Abraham*, per *G. E. Bodkin*).

This species is very near *P. comstocki*, Kuwana, as defined by Ferris (Leland Stanford Jun. Univ. Pub. "The California Species of Mealy Bugs," p. 41) but differs in having a larger number of cerarian spines and in the form of the chitinised area on the ventral surface of the anal lobes.

Taken in association with *Lecanium inquilinum*, Newst., and *L. deformosum*, Newst.

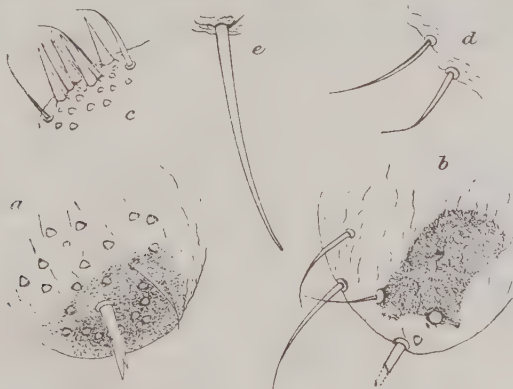


Fig. 3. *Pseudococcus inquilinus*, Newst., sp. n. ♀; a, dorsal and, b, ventral surface of anal lobes; c, lateral abdominal cerarii; d, body setae; e, hair of anal ring.

### ***Pseudococcus perniciosus*, Newst. & Willcocks, var.**

*Ovisac of female.* Arranged in a similar way to those of typical *P. perniciosus*,\* but the more or less globular masses are smaller. The examples are so badly weathered, however, that it is not possible to give details of the structure of the individual ovisacs.

*Female, adult.* Under pressure of the covering glass the form is narrowly ovate. Antennae of seven segments. One pair of cerarii present on the anal lobes (fig. 4, a), the spines sharp and somewhat slender, with a few obtusely triangular gland-pores scattered around them. No typical lateral abdominal cerarii present, but their position is indicated by a single, faintly lanceolate spine (fig. 4, c), with from 1 to 2 simple supplementary setae at some distance away from it: the spines are traceable in some individuals on the last 3-4 segments, in others on the penultimate segment only. Body spines (fig. 4, d) minute, faintly lanceolate, and very scanty indeed; hairs small and also very scanty. Anal lobe setae (fig. 4, b) slightly longer than the anal ring setae (fig. 4, e). Integument very thickly set with gland-pores (fig. 4, c, c), more especially so along the margin; these are of three kinds: multilocular, tubular and obtusely triangular; the first-named are arranged in narrow transverse bands on the dorsal surface of some of the abdominal segments, elsewhere they are irregularly disposed on both surfaces. Length of 53 adult ♀♀ varying between 2.1 and 2.7 mm.

\* Newstead & Willcocks. Bull. Ent. Res., i, p. 138 (1910).

*Larva.* Anal lobes with a pair of slightly lanceolate spines; setae longer than those of the anal ring. Dorsal spines minute, similar in shape to those on the anal lobes.

BRITISH EAST AFRICA: Kabete, on coffee, November 1918. "Coffee bush infected in the lab. has been killed by this scale" (*F. W. Dry*, for *T. J. Anderson*).

Typical examples of *P. perniciosus*, N. & W., have from 5-6 pairs of lanceolate cerarian spines on the distal segments of the abdomen, with 2-3 obtusely triangular pores scattered near them; and the body spines, though smaller than the cerarian spines, are relatively much larger, and also much more frequent than are those in the variety from coffee at Kabete. Moreover *P. perniciosus* is much larger, measuring from 3-4 mm.

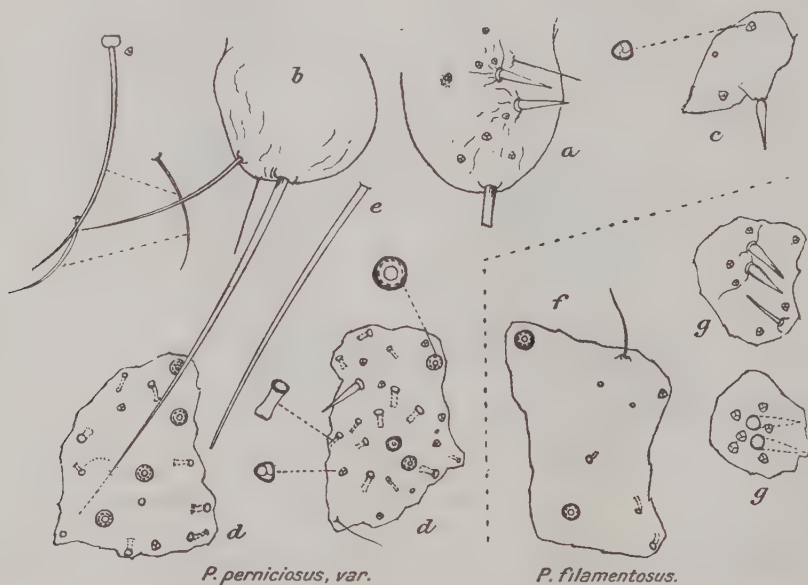


Fig. 4. *Pseudococcus perniciosus*, N. & W., var., ♀; a, b, dorsal and ventral aspect of the anal lobes; c, lateral abdominal cerarii; dd, gland-pores; e, hair of anal ring. *Pseudococcus filamentosus*, Ckll., ♀; f, gland-pores; gg, lateral abdominal cerarii.

Brain\* has sunk *P. perniciosus* as a synonym of *P. filamentosus*, Ckll., without giving reasons for so doing; this action has led me to re-examine examples of the latter (part of the type lot kindly presented to me by Professor T. D. A. Cockerell in 1892) and I find that it differs to a marked degree from *P. perniciosus* in having very few gland-pores (fig. 4, f), relatively shorter anal lobe setae and small groups of obtusely triangular pores round the cerarian spines (fig. 4, g, g). Some of the tubular ducts of the dorsum are also much shorter and many of them are accompanied by 2-3 obtusely triangular pores. Clearly therefore *P. perniciosus* is specifically distinct from *P. filamentosus*, and the former name must be retained.

\* Brain, C. K. Trans. R. Soc. S. Africa, v, pt. 2, p. 99 (1915).

**Phenacoccus ballardi**, Newst.

The original description\* of this rather remarkable insect was given without illustrations. I have thought it desirable, therefore, to give a photomicrograph of both old and young adult females (Pl. xvi, fig. 4) in the hope that it will enable students to determine the species with greater ease.

**Pseudophilippia inquilina**, sp. nov.

*Female, adult.* Form short ovate and slightly tumid. Colour in life mauve pink. Dorsum nude; venter protected by a thin vesicular glassy scale, which is firmly attached to the bark of the food-plant. Antennae (fig. 5, *a*) and legs quite rudimentary; the former, which are much shorter than the stigmata, are composed

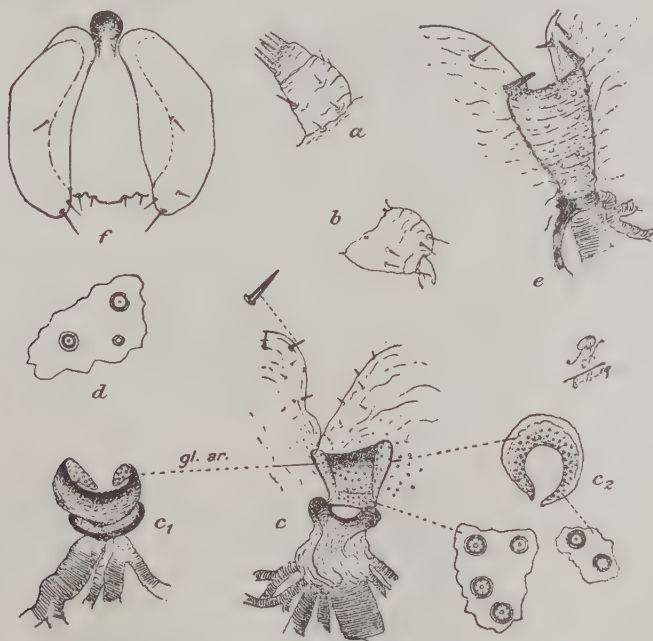


Fig. 5. *Pseudophilippia inquilina*, Newst., sp. n. ♀; *a*, antenna; *b*, leg; *c*, *c*<sub>1</sub>, *c*<sub>2</sub>, stigmata; *d*, gland-pores. Second stage ♀: *e*, stigmatic cleft; *f*, anal lobes.

apparently of three segments, the apex having several stiff hairs. Legs (fig. 5, *b*) slightly smaller than the antennae, bare, composed of a single tubercular-shaped segment, with a relatively large claw; lower digitules stout and bluntly pointed. Stigmatic clefts (fig. 5, *c*) clearly defined. The stigmata (fig. 5, *c*, *c*<sub>1</sub>, *c*<sub>2</sub>), which are placed close to the cleft, are protected by a well-defined external arch (fig. 5, *gl. ar.*) shaped somewhat like a horse-shoe in miniature, and closely set internally with thick-rimmed multilocular gland-pores. Anal cleft nearly four times the length of the lobes; the latter surrounded by a distinct chitinous arch. Venter rather

\* Newstead, R. Bull. Ent. Research, viii, p. 17 (1917).



thickly studded with circular gland-pores (fig. 5, *d*). Dorsum with numerous spines, especially towards the margin. Rostrum relatively large; the filaments protected by a very long membranous sheath. Length, 4.2–6.8 mm; width, 4.3–5.5 mm.

*Female, second stage.* Short ovate; dorsum flat. Colour and the structural characters of the antennae and legs as in the adult female. Stigmatic clefts (fig. 5, *e*) relatively deep. Stigmatic spines two, one on either side of the external glandular arch; the latter much more extended towards the margin, and with fewer gland-pores than in the adult; fulcrum to the atrium of the stigmata strongly produced. Anal lobes (fig. 5, *f*) with a tongue-shaped sclerite between them at the base.

*Larva.* Ovate. Antennae and legs well developed; the former of six segments, of which the 3rd is much the longest and equal in length to the 2nd, 4th and 5th together. Anal lobes large; apical hair very long and stout. One large stigmatic spine in each cleft. Marginal hairs in an irregular double row. Abdominal segments with a transverse series of hairs, slightly smaller than those at the margin. Rostral filaments as long, apparently, as the circumference of the body.

JAMAICA: on the banks of the Great River, near Montpelier; attached to the bark of an unknown tree beneath a large, blackish coloured "paper" nest of *Cremastogaster brevispinosa*, Mayr, var. *tumulifera*, For. The nest in question was attached to the bole of the tree about six feet from the ground; 10.xii.1908 (*R. Newstead*).

I have placed this rather remarkable insect in Cockerell's genus *Pseudophilippia* as it agrees best, in its morphological characters, with Cockerell's diagnosis; but the absence of an ovisac may be thought by other students to preclude its admission here. It seems to me, however, that the presence of a glassy ventral scale beneath the body of the female and the curiously protected stigmata do not in themselves call for the erection of a new genus.

### ***Antonina waterstoni*, sp. nov.**

*Female, adult.* Colour, in life, pale buff to dusky buff. Form flat, narrowly ovate to very elongate, broadly rounded in front, widest generally in the region of the proximal segments of the abdomen, narrowing rather suddenly behind; last two segments of abdomen (fig. 6, *a*) strongly constricted. Antennae quite rudimentary and apparently unsegmented; they are placed quite close to the margin. Legs absent. Mentum very small and unsegmented; just below it there are several minute tubercles, each with a short stiff hair. Stigmata large and widely separated; first pair in a line with the rostrum; the small group of parastigmatic glands merging into those at the margin. On the dorsal surface just behind the 2nd pair of stigmata is a large group of minute spines (fig. 6, *b*) occupying the whole width of the 1st proximal segment of the abdomen. Margin, all round, with an almost continuous band of relatively large pores (fig. 6, *c*) and a few minute pointed spines. Anal segment (fig. 6, *a*) markedly distinct; dorsal surface with a pair of forwardly directed bristles; ventrally it is almost covered with pores, which are almost as numerous as those on the preceding segment. Anal lobes quite rudimentary, each bearing a few stiff hairs. Anal ring (fig. 6, *a*<sub>1</sub>) placed in a slight depression; hairs six in number, and rather stout. Length of young adult, 3–4.2; width, 2–3.2 mm. Old adults measure: length, 5.7–6 mm; width, 3–3.2 mm.

The dorsum and venter are very thinly protected with white powdery wax, this secretion adheres to the food-plant, but readily comes away from the insect: beyond the body, especially in the posterior region, the secretion is dense and completely fills the narrow space between the stem and the leaf-sheath. The general of facies the female, together with the secretory matter (ovisac), bears a striking resemblance to *Aclerda berlesei*, Buffa.



Fig. 6. *Antonina valerstoni*, Newst., sp. n., ♀; a, terminal segments of abdomen; a<sub>1</sub>, terminal segment of abdomen with anal ring, etc.; b, gland-pores and body spines; c, marginal gland-pores; d, dorsal aspect of pupa; e, leg i. of pupa; f, antenna of larva.

*Male* (fig. 7, a). Rather robust. Head almost as broad as the thorax. articulation faint. Eyes well within the margin, and enclosed by two longitudinal curved sclerites; ocelli slightly smaller, placed between the antennae, just within the margin of the frons, ventrally. Antennae (fig. 7, b) of nine segments; 1st and 2nd very robust;

3rd and 4th very slender and markedly narrower than the rest ; 4th much the smallest and less than half the length of the 3rd ; all the segments with the exception of the 4th and 9th with short stout, bluntly pointed spines ; terminal one with several long hairs. Leg i. (fig. 7, c) with the tibia and tarsus more robust and much shorter than the corresponding segments in legs ii. and iii. (fig. 7, d) ; all the tibiae with distal spines, ventrally. Genital sheath short. Caudal bristles long. Wings long, but rather narrow. Length to end of genital sheath, 0·8.

*Pupa* (fig. 6, d). Robust. Antennal sheaths short and composed, as far as one can ascertain, of nine segments. Leg i. (fig. 6, e) more robust than legs ii. and iii. Claws to tarsi very slender. Length, 0·8 mm.

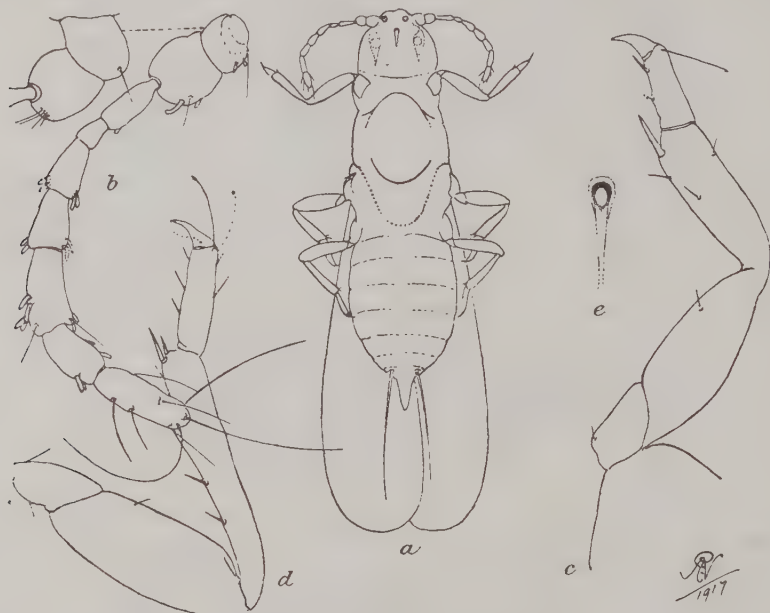


Fig. 7. *Antonina waterstoni*, Newst., sp. n., ♂ ; a, ventral view ; b, antenna ; c, leg i ; d, leg iii ; e, vestigial buccal cavity (?)

*Puparium of Male*. Three of these were found closely packed together under a leaf-sheath in association with the females. Collectively they formed an irregular mass of white, loosely felted and brittle strands of wax, completely enclosing the pupae.

*Larva, adult* (? Male). Very elongated, parallel-sided. Antennae (fig. 6, f) of six segments ; 3rd shortest ; 6th longer than the first three together ; all the segments with fine hairs, the 5th and 6th with long slender spinose ones. Anal segment of abdomen with a long stiff bristle indicating the position of the lobes. Anal ring with six long hairs. Rostrum very broad. Eyes small but prominent. Length, 0·55 mm.

MACEDONIA : beneath the leaf-sheaths of *Arundo phragmites*, 1917 (Capt. James Waterston).

It affords me infinite pleasure to dedicate this newly discovered species to our esteemed colleague.

The males were all dead, and more or less imperfect; and although one failed to trace the long caudal filaments, the presence of these structures is indicated by the setae which supports them in life. All the examples were lying beneath the leaf-sheaths and were flattened out as if by pressure of the sheaths.

The male of *Antonina australis*, Green, has been seen by Froggatt (Agricultural Gazette, N.S.W. No. 742, p. 3, 1904), but so far as I can ascertain it has not been described. The discovery therefore of the male of *A. waterstoni* is of interest, as the members of this sex in all the other species hitherto described are unknown.

The female of *A. waterstoni* is nearly related to *A. socialis*, Newstead, but differs in having much smaller antennae, in the presence of a large isolated group of minute spines, and in the character of the anal segment, including also the relative position of the anal ring.

***Pseudokermes marginatus*, sp. nov.**

*Female Test.* Roughly hemispherical; glassy white, with a median longitudinal suture, which renders the two halves easily separable; dorsal surface with faint traces of small and somewhat rectangular patches of secretion; sides with wavy conchoidal striae; stigmatic ridges more or less distinct; margin wavy.

*Female, adult.* Shape somewhat like that of a soldier's steel helmet in miniature, with a narrow mediodorsal ridge, a relatively very broad flat margin (rim) and prominent anal lobes. Surface faintly uneven but shining. Colour pale castaneous. Boiled in KOH, the integument of the dorsum changes to pale straw-colour; the broad flange becomes quite transparent, and the extreme margin brownish—the three grades of chitin showing in marked contrast to one another. Antennae represented by exceedingly minute tubercles bearing 4–5 short stout setae. Legs entirely absent. Margin wavy and irregular. Stigmata robust, somewhat cylindrical, and externally obtusely conical. Stigmatic clefts and spines absent. Marginal spines relatively stout, acutely pointed, and very widely separated. Anal cleft deep; lobes somewhat triangular, the proximal and inner margins longer than the outer; apices with several fine hairs. Dorsal gland-pores in the median longitudinal ridge, circular, surrounded by a small pale area, and often divided into two linear groups. The broad flat marginal flange, in very old and heavily stained examples, with numerous cell-like clear areas, the inner series forming an irregular dactyliform pattern; in younger forms these structures are wanting and in their place are seen a large number of narrow tubular ducts. The extreme margin presents, on its inner surface, an irregular crenulated appearance, the depressions occupied by a rather ill-defined duct. Length, 2.1–1.8; width, 2.1–2 mm.

BRITISH GUIANA; Ituni Savannah, on *Nectandra* sp.; 28.ii.1919 (*A. A. Abraham* per *G. E. Bodkin*).

The test of the female resembles that of the young forms of *P. nitens*, Ckll., but the fine vertical striae are wanting and the surface is much more uneven. In the female of *P. nitens* the broad margin is wanting; the integument is uniformly membranous after maceration in KOH, and minute vestigial legs are present.

Male puparia not observed.



***Pulvinaria brevicornis*, sp. nov.**

*Female, adult.* More or less oval in outline and highly convex, or sub-hemispherical; generally with two longitudinal rows of rather deep pits, one on each side of the median line. Colour, in alcohol, varying from pale buff to pale castaneous; some are unicolorous, others with two interrupted longitudinal black lines following the course of the pits, the outer line, in some examples, giving off lateral lines on the abdominal segments. Integument thin. Antennae (fig. 8, *a*) relatively very short and robust, equal in length to the anterior tibio-tarsal segments together; of 6 segments (the articulations somewhat ill-defined in some examples); 5th and 6th each with a rather long slender spine. Legs (fig. 8, *b*) short and very robust. Stigmatic clefts obsolete; spines three (fig. 8, *c*), stout, the central one generally slightly

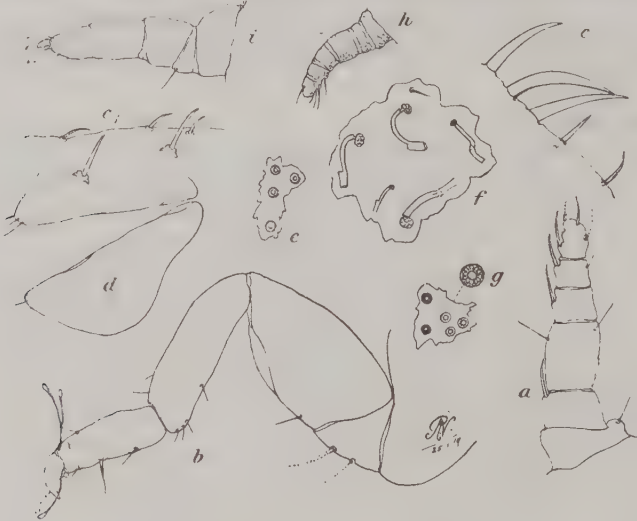


Fig. 8. *Pulvinaria brevicornis*, Newst., sp. n., ♀; *a*, antenna; *b*, leg; *c*, *c*<sub>1</sub>, stigmatic and marginal spines; *d*, anal lobes; *e*, preanal gland-pores; *f*, ventral tubular ducts; *g*, stigmatic gland-pores. Male, pronymph: *h*, antenna; *i*, leg.

longer than the laterals, but in some instances it is of the same length as the others. Marginal spines (fig. 8, *c*<sub>1</sub>) simple, pointed and rather widely separated. Anal cleft short, or two to three times longer than the lobes. Anal ring of 10 hairs. Anal lobes (fig. 8, *d*) with the proximal margin much longer than the distal margin; apex with several hairs. Dorsum, in heavily stained preparations, with widely separated, broadly oval or subcircular cells. Venter with innumerable circular gland-pores, the tubular connections of which (fig. 8, *f*), are suddenly truncate on one side near the proximal end and furnished with a rosette-like extension. Length, 3-3.75 mm; width, 1.75-3 mm.

BRITISH GUIANA: Turkey, East Coast, on *Avicennia nitida*, 22.vi.1917 (*G. E. Bodkin*).

The integumental characters of this insect are unusual, and should serve, together with the form of the antennae, the anal lobes and stigmatic spines, to distinguish it from its allies.

**Pulvinaria broadwayi** var. **echinopsidis**, nov.

*Female, adult.* Ovate, usually very slightly narrowed in front. Antennae of eight segments; 3rd a little longer than the 2nd; formula 3, 2, 8, 1 (4, 5, 6, 2) or 3, 2, 8, 4 (5, 6, 7). Legs robust and relatively long. Lower digitules strongly incrassate proximally and broadly dilated distally. Stigmatic clefts (fig. 9, *a*) very shallow; spines three, all of them stout, the middle one usually a little more than twice the length of the laterals. Marginal spines (fig. 9, *a*) set rather closely together and of two types—one relatively short and simple, the other longer and slightly divided

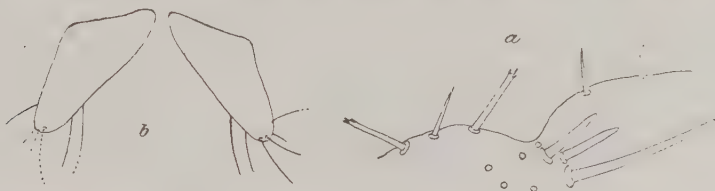


Fig. 9. *Pulvinaria broadwayi* var. *echinopsidis*, Newst., nov., ♀;  
*a*, stigmatic cleft with marginal and stigmatic spines; *b*, anal lobes.

at the tip. Dorsum without glands or cellular structures; venter crowded with glandular tubes, more especially so in the abdominal region. Anal lobes (fig. 9, *b*) rather narrow and furnished distally with several long hairs. Anal ring of eight hairs, of which one pair is much smaller than the rest. Length, 2-1.5; width, 1-1.3 mm.

*Ovisac.* More or less rounded and formed of loose and somewhat brittle material, at the side of which the shrivelled body of the female rests. Greatest width, 1.5-3 mm.

BRITISH GUIANA: Botanic Gardens, Georgetown, on *Echinopsis latiflora*, ix.1918 (G. E. Bodkin and H. Morrison).

**Lecanium subacutum**, sp. nov.

*Female, adult* (fig. 10, *a*). Colour of dead examples pale dusky yellow. Flat and very thin; dorsum wrinkled, the wrinkles at the margin radial. Form long and narrow; extremities subacute; the length three times as great as the greatest width; one side of the body is usually more or less straight, the other strongly arched. Antennae (fig. 10, *b*) of six segments, the third very long, and almost equalling the length of the 2nd, 4th, 5th, and 6th together. Legs long and slender. Stigmatic clefts (fig. 10, *c*) shallow; spines three, all of them very stout and bluntly pointed; the central one rather flattened and more than twice the length of the laterals. Marginal spines (fig. 10, *c*) simple, rather stout and strongly curved backwards; they are placed very closely together, so that the tip of each spine almost reaches the strongly curved portion of the spine below it. Anal lobes (fig. 10, *d*) long and narrow; the length equalling that of the 3rd segment of the antennae. Dorsum with numerous large circular gland-pores (fig. 10, *e, e*) having strongly chitinated rims and fine granular centres; they are irregularly scattered over a relatively broad area between the anal lobes and the antennae. Dorsal spines (fig. 10, *e, e*) short, stout, and bluntly pointed. Dermal cells absent. Submarginal tubercles in two

pairs: one anterior, the other posterior. Anal cleft relatively short, and from one-seventh to one-ninth the length of the body. Length, 2.4–3.1 mm.

Young females are relatively narrower than the adults; but do not otherwise differ from them.

*Male puparium.* Glassy white. Very elongate; outline similar to that of a young female; median plate or "coronet" long and very narrow; stigmatic ridges well defined; margin with one division along the line of the lower pair of stigmata. Length, 1.8–1.9; width, 0.5–0.6 mm.

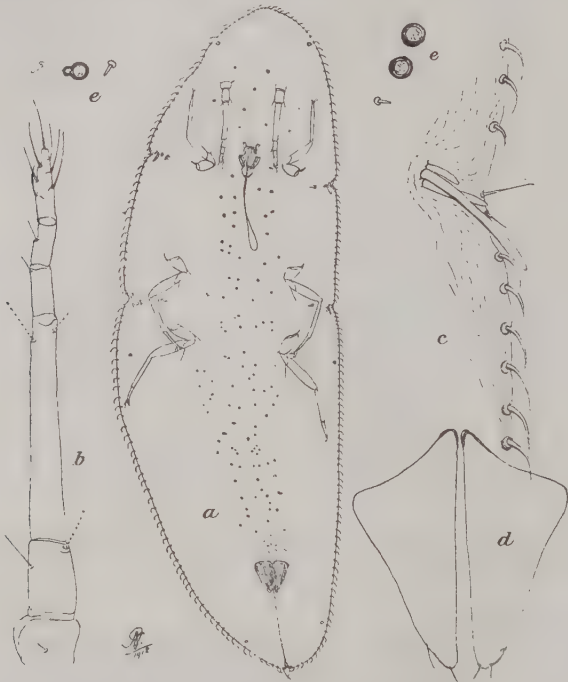


Fig. 10. *Lecanium subacutum*, Newst., sp. n., ♀; a, adult ♀; b, antenna; c, marginal and stigmatic spines; d, anal lobes; e, e, dorsal gland-pores and spines.

UGANDA: Jana Isl., Sesse Islands, Lake Victoria, on *Coffea robusta*, 9.x.1918; Bufumira Isl., Sesse Islands, on the leaves of an unknown plant, 12.x.18 (C. C. Gowdey).

In both instances this species was living in association with *Aspidiotus articulatus* var. *magnospinus*, Newst.

#### ***Lecanium (Eucalymnatus) decemplex*, sp. nov.**

*Female, adult.* Circular, or more or less so; flat and very thin. Colour translucent amber-yellow, often with a tinge of red or pale castaneous. The whole of the dorsum covered with a thin hard glassy test, the presence of which is extremely difficult to detect and which is equally hard to detach. Boiled in KOH the female

(fig. 11, *a*) presents the following morphological details: Dorsum divided into five bilateral plates—two cephalic, three thoracic, and two abdominal; the sutures separating the cephalic from the first thoracic plates terminating at the stigmata; the other sutures are connected with the mesal one (these sutures in the dried examples appear as well defined narrow ridges). Mesal suture between the anal lobes and the rostrum with large circular gland-pores (fig. 11, *b*). Antennae of six segments; the third almost as long as the 1st, 4th, 5th and 6th together. Legs well developed; lower digitules large and strongly incrassate. Anal lobes (fig. 11, *c*) somewhat triangular; inner margin longest; distal margin shortest; the sclerites beneath (fig. 11, *d, d*) stout and somewhat spine-like. Anal cleft deep, and apparently partly fused but separable. Stigmatic clefts (fig. 11, *e, e*) small, but deeply invaginated; spines three, very robust, and blunt at the tips. Marginal spines (fig. 11 *e, e*) simple, and set rather widely apart. Submarginal gland pores (fig. 11, *f*) very small, numbering from six to eight on either side. Oval cells can be seen, near the margin, in old and well stained examples. Length, 3.4–3.7; width, 3.2–3.7 mm.

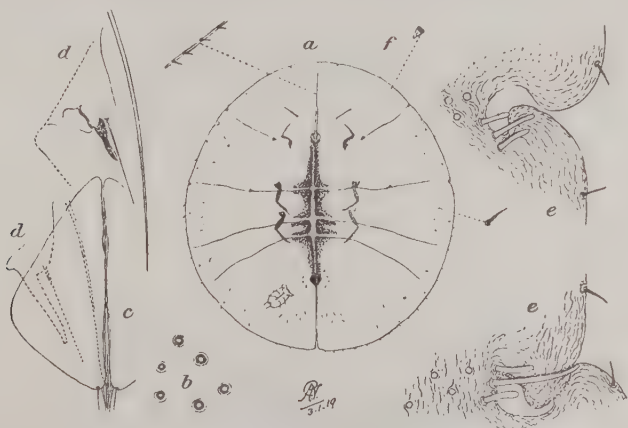


Fig. 11. *Lecanium (Eucalymnatus) decemplex*, Newst., sp. n., ♀; *a*, adult ♀; *b*, mesal gland-pores; *c*, anal lobe; *d, d*, sclerites of anal lobes; *e, e*, stigmatic clefts and spines.

*Male Puparium.* Broadly ovate; divided into eleven plates: two median, one cephalic, and four bilateral; the lateral plates with partial subdivisions. Length, 1.8; width, 1.4 mm.

BRITISH GUIANA: Ayaria, Thuraka Lake, Ituribisci Creek, Essequibo, on leaves of *Lecythis* sp., 6.x.1918 (*G. E. Bodkin*).

This somewhat remarkable species evidently belongs to the subgenus *Eucalymnatus*, its distinguishing features being the small number of plates into which the dorsum is divided.

### ***Lecanium inquilinum*, sp., nov.**

*Female, adult.* Ovate or elongate and highly convex; more or less circular when mounted under pressure. Integument pale brown, but thin and transparent after maceration in KOH. Antennae (fig. 12, *a*) of eight segments. Legs relatively robust



and rather long; digitules normal. Anal cleft free and a little more than twice the length of the lobes; the latter (fig. 12, *b*) rather elongate and obtusely rounded distally. Stigmatic clefts very small; spines three, all robust and blunt, the laterals almost equal in size to the central one. Marginal spines (fig. 12, *c*) long and very acute, the tips in many cases appearing almost flagellate; they are placed very closely together and are continuous along the stigmatic clefts. Stigmata with a large trumpet shaped peritreme, and placed unusually near the margin of the body. There is a large closely packed group of multilocular gland-pores on the inner walls of the anal cleft, close up to the lobes. A few minute gland-pores occur in the densely chitinous patch surrounding the anal lobes. Length, 1.7–2.3; width, 1.4–1.8.

*Female, young adult.* Similar to the old adult, but the marginal spines are much more bluntly pointed and the chitinous patch surrounding the anal lobes is wanting.

BRITISH GUIANA: "Cattle Trail Survey," the insects enclosed by ants (*Acromyrmex* sp.) in small paper nests 1919 (*A. A. Abraham* per *G. E. Bodkin*).

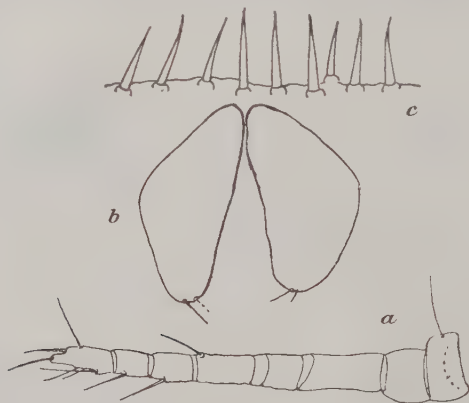


Fig. 12. *Lecanium inquilinum*, Newst., sp. n., ♀; *a*, antenna; *b*, anal lobes; *c*, marginal spines.

The form and arrangement of the marginal spines recall those seen in certain species of *Pulvinaria*; but the species clearly belongs to *Lecanium* and somewhat resembles the hollow hemispherical species. Taken in association with *Lecanium deformosum*, sp. n., and *Pseudococcus inquilinus*, sp. n.

### ***Lecanium (Eulecanium) deformosum*, sp. nov.**

*Female, adult* (fig. 13, *a–d*). Dorsum rather flat; sides relatively thick; general form very irregular and distorted, some examples being broader than long and others more or less elongate, but the margins in all cases (12 examples) are asymmetrical and often distorted to a marked degree. Antennae (fig. 13, *e*) of six segments; the 3rd and 6th longest. Legs with the tibio-tarsal segments either distinctly articulated or partly so, rarely completely fused; leg i. (fig. 13, *f*) with the tibia generally strongly curved. Anal lobes (fig. 13, *g*) very broadly dilated distally. Anal cleft faintly fused, but easily separated after maceration in KOH. Stigmatic clefts small, or seated in faint depressions; spines (fig. 13, *h*) three, the laterals normally very short, stout.

and obtusely pointed: in one example (fig. 13, *h*<sub>1</sub>) the lower group on one side has the lateral spines as long and as stout as the central one. Marginal spines (fig. 13, *i*) simple and hair-like. Dorsal gland-pores minute and widely separated. In well stained specimens the integument of the dorsum is faintly divided into broad plate-like radial areas enclosing numerous irregular pigmented markings. Length, 1.2–1.8; width, 1.1–1.5, mm.

BRITISH GUIANA: "Cattle Trail Survey," on an unknown plant, the insects enclosed by ants (*Acromyrmex* sp.) in small paper nests, 1919 (*A. A. Abraham* per *G. E. Bodkin*).

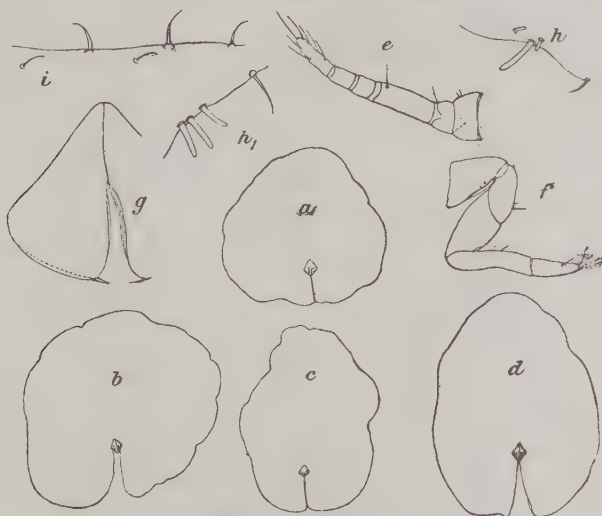


Fig. 13. *Lecanium deformosum*, Newst., sp. n., ♀; *a-d*, outline of four adults; *e*, antenna; *f*, leg; *g*, anal lobes; *h*, *h*<sub>1</sub>, stigmatic spines; *i*, marginal spines.

A small oviparous species, remarkable for its markedly deformed shape, the presence or absence of the tibio-tarsal articulation, and the apparent variability of the stigmatic spines. Found in association with *Pseudococcus inquilinus*, sp. n., and *Lecanium inquilinum*, sp. n.

### ***Lecanium* (Saissetia) *nigrum* var. *nitidum*, nov.**

*Female, adult.* Usually more or less hemispherical, but some examples are slightly ovate and narrowed in front; margin markedly flattened, and often with regular rectangular patches of silvery secretion; dorsum smooth and shining; anal lobes usually porrect. Colour varying according to the age of the individual: young forms pale red-brown, old adults rich dark castaneous. Eyes relatively large, black and prominent. Antennae (fig. 14, *a*) of eight segments; the 3rd scarcely as long as the 4th and 5th together. Legs rather slender. Derm cells forming a closely reticulated pattern as in *Lecanium nigrum*, Niet. Stigmatic clefts very shallow; spines three, the central one about five times the length of the laterals, (fig. 14, *b*). Marginal

spines (fig. 14, *c*) short and sub-palmate, the distal portion being broadly flattened and deeply divided. Anal lobes (fig. 14, *d*) short and obtusely rounded; inner margin slightly longer than the proximal; external margin strongly arched. Length, 1.8-2 mm.

*Female, young adult.* Flat; straw-coloured when dry. Form when mounted under pressure somewhat ovate. Antennae (fig. 14, *a*) with eight segments and similar in form to those of the adult. Legs ii. and iii. much longer than leg i. Stigmatic clefts (fig. 14, *b*) indicated by a very slight indentation of the margin; spines three, the laterals minute and acutely pointed. Marginal spines (fig. 14, *b, c*) as in the adult. Anal cleft free, its length slightly less than twice the length of the lobes; the latter (fig. 14, *d*) as in the old adults.

UGANDA: Bukeke Isl., Sesse Islands, Lake Victoria, on *Luzibarziba*, 9.x.1918 (*C. C. Gowdey*).

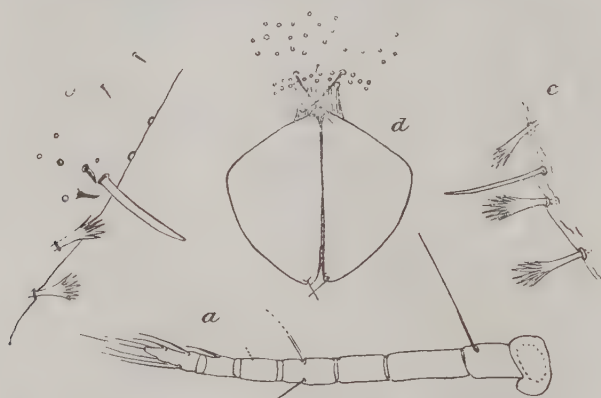


Fig. 14. *Lecanium nigrum* var. *nitidum*, Newst., ♀; *a*, antenna; *b*, stigmatic and marginal spines; *c*, marginal spines; *d*, anal lobes.

Its small size and generally hemispherical form, together with the highly polished integument and the sub-palmate marginal hairs, are the distinctive features of this well-marked variety.

### ***Platysaissetia montrichardiae*, sp. nov.**

*Female, old adult.* Blackish or sooty brown. Generally more or less ovate and very slightly narrowed in front; but occasionally the outline is irregular, indented, or markedly asymmetrical; dorsum very low convex or almost flat, scabrous, the minute elevations often carrying small particles of the test of the young female. Vertical sides markedly shallow. Pseudo-margin relatively faintly produced. Tubular glands at the extreme margin. Stigmatic clefts rarely traceable. Venter hollow, but more or less covered with a rather thick pellicle of white wax. Dermal cells (fig. 15, *a*, from an *unstained* preparation) very irregular in outline, each pale area with a distinct pore at the extreme edge; the walls of each cell area thick, dark, and very irregular. Other details as in the young adult. Length 4-5.2; width 2.9-3.9. mm.

*Female, young adult.* Pale brown to dull castaneous. Dorsum flat and covered with a dirty white, glassy test, consisting of minute plates, which collectively present a faintly imbricated appearance. The test is easily deciduous, and when removed the integument presents a polished appearance. Antennae (fig. 15, *b,b*) of eight segments, of which the 4th, 5th and 8th are the longest; formula: (4, 5, 8) 3, 2, (6, 7) 1 or 5 (4, 8, ) 3 (2, 6, 7) 1; terminal hair of great length. Legs relatively slender; tarsus of anterior pair (fig. 15, *c*) with a well defined constriction; coxa and trochanter each with a very long hair. Stigmatic clefts obsolete; spines (fig. 15, *d,d*) three, the central one equal in length to the 4th and 8th segments of the antennae; lateral spines pointed and about one-fourth the length of the central one. Marginal spines (fig. 15, *d*) slightly shorter and stouter than the lateral stigmatic spines; they are

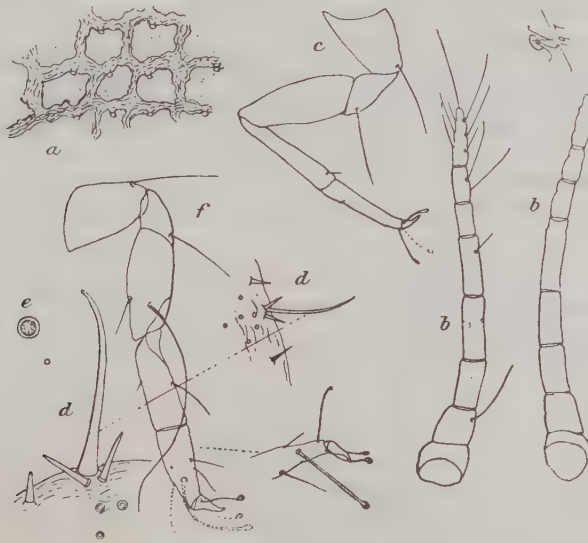


Fig. 15. *Platysaissetia montrichardiae*, Newst., sp. n., ♀; *a*, dermal pores and "cells." Young adult ♀; *b, b*, antennae; *e*, leg; *d, d*, stigmatic spines; *e*, post anal gland-pores; *f*, leg of larva.

separated by a distance equal to three or four times their length. Dermal gland-pores irregularly ovate, large, placed close together, and most conspicuous towards the margin. Anal lobes with the outer margin strongly arched; and surrounded by a narrow wall of dense chitin. Anal cleft fused; from one-fifth to one-sixth the length of the body. Postanal glandular pores (fig. 15, *e*) relatively large and circular, forming a broad scattered group extending as far forward as the mentum. Length, 2.6–3.3 mm.

*Female, second stage.* Differs from the adult chiefly in the following details: Antennae of six segments, of which the third is much the longest. Postanal gland-pores absent; postanal bristles in three pairs. Length, 0.7–0.8 mm.



*Male Puparium.* Oblong, opaque, glassy, white; anal cleft distinct; surface composed of minute rough polygonal plates; the marginal series forming a roughly serrated fringe. Length, 1.5 mm.

*Larva.* Differs from the second stage female in the following details: Antennae with the 3rd and 6th segment equal and longest. Legs (fig. 15, *f*) with the distal femoral bristle of great length; tarsal digitules markedly unequal in thickness and length respectively, the longer one arising from the tarsus some distance behind the smaller one; digitules to the claw normal. Anal ring with six hairs. Length, exclusive of the caudal bristle, 0.5 mm.

BRITISH GUIANA: Ikruaka Lake, Essequibo, on *Montrichardia aculeata*, 11. iii. 1917 (*G. E. Bodkin*).

A very heavy infestation, so much so that the insects covered a very large proportion of the branches.

A somewhat remarkable species, distinguishable, in the adult female, by the curious character of the derm and the relatively short anal cleft (0.7–0.8 mm.); in the second stage female by the absence of marginal cylindrical ducts to the glands; and in the larva by the unusual character and relative position of the tarsal digitules.

### ***Aspidiotus longispina*, Morgan.**

*Aspidiotus longispina*, Morgan, Ent. Mo. Mag. xxv, p. 352, pl. v, fig. 1 (1889).

*Morganella maskelli*, Cockerell, Bull. 6, T.S., U.S.A. Dept. Agric., p. 22 (1897).

*Hemiberlesia longispina* (Morg.), Leonardi, Riv. Pat. Veg. vi, p. 120, fig. 4 (1897).

*Aspidiotus longispina* var. *ornata*, Maskell, Trans. N.Z. Inst., xxx, p. 225 (1897).

*Aspidiotus* (*Morganella*) *maskelli* (Ckll.) Brain, Bull. Ent. Research, ix, p. 136, pl. vii, fig. 109 (1918).

*Female Puparium* (fig. 16).—This, when perfect, is narrowed, strongly produced, and slightly involute posteriorly, resembling the long curved toe of an Oriental slipper in miniature. This very remarkable appendage is composed of both dorsal and ventral portions of the capsulate puparium; but it is rarely found intact in examples which have been submitted to even light pressure, as it is very brittle and readily breaks away.



Fig. 16. *Aspidiotus longispina*, Morgan, ♀, puparium.

*Male Puparium.* Elongate, exuviae terminal or sub-terminal. Colour as in the female puparia.

*Male.* Not differing in its morphological characters from typical members of the genus.

BRITISH GUIANA: Botanic Gardens, Georgetown, on papaw, 1919 (*G. E. Bodkin*).

The synonymy given above is, I believe, correct, the determination being based upon an examination of material received from both Morgan and Maskell. A co-type ♀ from Morgan in my collection was originally mounted in Canada balsam without staining, so that the true form of the strikingly characteristic squamae on the pygidium of the ♀ could not be detected and was thus overlooked by Morgan in the first instance, and subsequently also by Leonardi, to whom I sent my example for examination, and for the purpose also of figuring it in his memoir (*l.c.*). In 1906 I had occasion to stain the female given to me by Morgan for comparison with examples submitted to me by Kotinsky, on *Ficus* sp., from Honolulu. I then found that the squamae were strikingly different from what they appeared to be when unstained. Subsequently I stained and mounted an example of Maskell's *A. longispina* var. *ornata* and found it to be specifically identical with Morgan's co-type female. Clearly therefore the specific names *maskelli* of Cockerell and *ornata* of Maskell must sink.

***Aspidiotus (Chrysomphalus) apicatus*, sp. nov.**

*Female Puparium.* More or less circular, convex and very thick; covered with a relatively thick epidermal layer of the bark; colour, when denuded, opaque black, larval exuviae nude, shining black, forming a well defined nipple; second exuviae black; ventral surface shining black. Ventral pellicle rather stout; white or dusky white, with a dark brown or blackish periphery. Diameter, 1.6–1.9 mm.

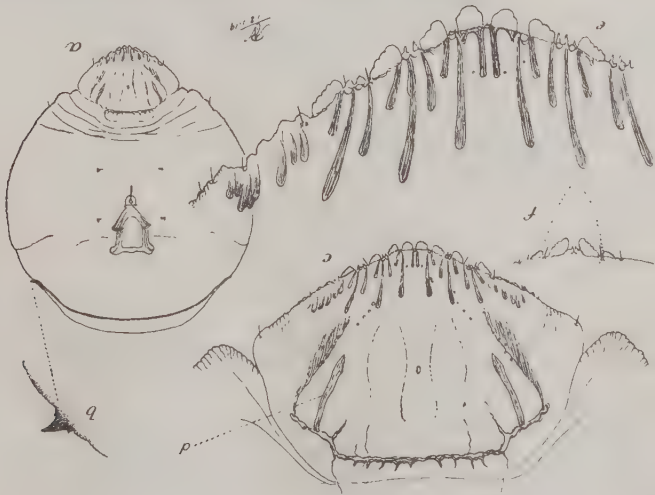


Fig. 17. *Aspidiotus (Chrysomphalus) apicatus*, Newst., sp. n., ♀; a, adult; b, thoracic spine; c, pygidium; d, paraphyses of do.; e, fringe of do.; f, anal plates, etc., of larva.

*Female, adult* (fig. 17, a). Broadly ovate, with a well marked and rather highly chitinised, cephalic projection, and immediately below it a minute spiny process (fig. 17, b). Margin of body more or less strongly and finely crenulated. No parastigmatic glands. Pygidium (fig. 17, c) broadly rounded, with a well marked callosity extending along it proximally, from which there arises on either side a somewhat

lanceolate sclerite (fig. 17, *d*). Margin (fig. 17, *e*) with nine pairs of well defined paraphyses and a few rather indistinct ones beyond them; those arising from the distal lateral portions of the lobes with the sides almost parallel and the ends more or less suddenly truncate. Lobes in four pairs; the 2nd, 3rd and 4th pairs dentate. Length, 1-1.1 mm.

*Male Puparium.* Broadly ovate, with the ends equally rounded; colour dark brown or blackish, but covered with the epidermal layer of the bark; larval exuviae black and more or less exposed; under surface dark brown or piceous, the central area partly covered with a white mealy secretion. Length, 0.5-0.6 mm.

*Larva.* Broadly ovate. Antennae of five segments, of which the 5th is much the longest and distinctly ringed. Pygidium (fig. 17, *f*) with two pairs of finely dentate lobes; the median pair much the larger and converging towards the middle line.

BRITISH GUIANA: Enmore Forest, East Coast, Demerara, on *Avicennia nitida*, ix.1918 (*G. E. Bodkin* and *H. Harrison*).

***Aspidiotus (Chrysomphalus) umboniferus*, sp. nov.**

*Female Puparium.* More or less circular to broadly pyriform; flat, thin, and somewhat transparent; pale reddish-brown to pale chocolate-brown. Exuviae



Fig. 18. *Aspidiotus (Chrysomphalus) umboniferus*, Newst., sp. n., *a*, larval and nymphal pellicles; *b*, adult ♀ after treatment in KOH; *c*, unrestored ♀; *d*, antenna of ♀; *e*, pygidium of ♀.

central or subcentral: the first nipple-like and black when denuded; the second, sooty brown. Ventral pellicle very delicate and composed generally of concentric rings. Diameter, 1.6-2 mm.

*Male Puparium.* Elongate ovate, slightly narrowed posteriorly. Colour similar to that of the female. Length, 1 mm.

*Female* (fig. 18, *b*, *c*). Very broadly pyriform; width of cephalothorax slightly greater than the entire length of the body; metathorax with a relatively large, blunt, marginal tubercle, which, together with the margin below it, is strongly

chitinised. Pygidium (fig. 18, e) unusually narrow and bluntly pointed. Circumgenital glands in four groups, the posterior lateral groups placed in a line with the vaginal orifice; formulae of four individuals:—

8-6	6-6	7-8	6-6
6-6	6-6	5-6	6-6

Lobes in three pairs; median pair somewhat quadrate, broader than long; 2nd and 3rd pairs slightly shorter than the first and more than twice as broad as long. Squamae between the median and 2nd lobes, very short; the second of the proximal pair, immediately beyond the third lobe, trifid. Paraphyses in six pairs, all rather narrow but clearly defined. Dorsal gland-pores small and few in number, with the tubular ducts filiform.

BRITISH GUIANA: Ayaria Creek, Essequibo, on *Lecythis* sp., 6.x.1918 (*G. E. Bodkin*).

In the structural details of the margin of the pygidium this species very closely resembles *A. perseae*, Comst., but it has a much more strongly pointed pygidium, fewer circumgenital glands, and an extra pair of paraphyses; these characters, taken in conjunction with the large metathoracic tubercles and the strongly chitinised margin below them, form the salient features of this Coccid. *Aspidiotus* (*Chrysomphalus*) *pandistus*, Hempel, also possesses very distinct cephalo-thoracic tubercles; but in this species there are only two pairs of paraphyses and the pygidium is relatively shorter and much more rounded distally.

***Aspidiotus* (*Selenaspidus*) *articulatus* var. *magnospinus*, nov.**

This variety (fig. 19, a) differs from typical *Aspidiotus articulatus*, Morgan, in the following details: Cephalothoracic margin finely but distinctly serrated. Thoracic

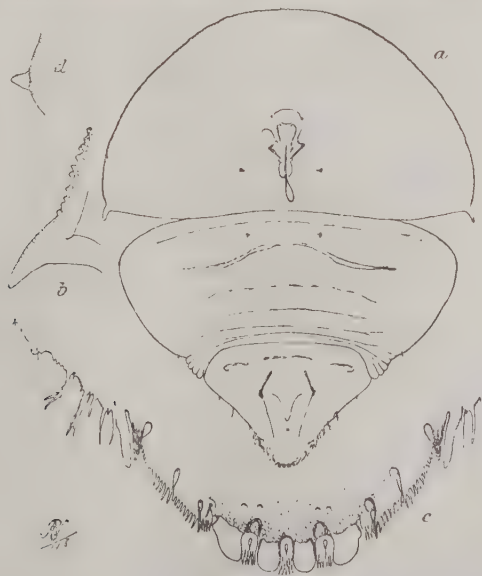


Fig. 19. *Aspidiotus articulatus* var. *magnospinus*, Newst., ♀; a, adult; b, thoracic spine; c, fringe of pygidium; d, thoracic tubercle of typical ♀ *articulatus* for comparison.



spine (fig. 19, *b*) relatively very large, curved and rather acutely pointed, the contour gradually merging into the cephalo-thoracic margin, and considerably longer than its greatest width. In *articulatus*, the thoracic spine (fig. 19, *d*), drawn to the same scale as in fig. *b*, is suddenly produced, short, and bluntly pointed, and its length about equal to its greatest width.

UGANDA: Bufumira Isl., Sesse Islands, Lake Victoria, on the leaves of an unknown plant, 12.ix.1918 (*C. C. Gowdey*).

*Aspidiotus (Selenaspidus) kamerunicus*, Lind., has a similar thoracic spine and a serrated margin, but in this species the broad palmate squamae, between the second pair of lobes and the spiny process, are replaced by squamae of a much narrower type.

***Aspidiotus (Odonaspis) rhizophilus*, sp. nov.**

*Female Puparium*. Dense, hard and capsulate, but the two halves slightly separated posteriorly. Form irregular, but old examples are slightly narrowed and produced posteriorly; convex above and flat beneath. Larval exuviae generally



Fig. 20. *Aspidiotus (Odonaspis) rhizophilus*, Newst., sp. n. ♀;  
*a*, pygidium; *b*, fringe of pygidium.

towards the anterior margin, greyish in colour and sometimes fissured. Ventral pellicle with a greyish patch towards the anterior margin. Texture rather rough; colour dull black or brownish black. Length, 1.3–1.5 mm.

*Female, adult*. More or less circular, or peg-top-shaped. Rudimentary antennae with, apparently, only one stout bristle. Stigmata surrounded by intricate folds of the integument; no gland-pores. Pygidium (fig. 20, *a*) very short and broadly rounded distally; circumgenital glands absent. Dorsal gland-pores small and few in number, the tubular ducts relatively long and slender. Ventral gland-pores similar to those on the dorsal surface, but more numerous. Vaginal orifice nearly opposite the anal orifice. Margin (fig. 20, *b*) with a series of irregular, closely adjacent, squamate plates, of which the larger pair are evidently homologous with the median lobes in typical members of the genus *Aspidiotus*.

BRITISH EAST AFRICA: Kabete, on roots of *Chloris incompleta*, 7.x.1918 (R. H. Deakin, per F. W. Dry).

***Aspidiotus fiorineides*, sp. nov.**

*Female Puparium* (fig. 21, a). Attached to the edge of the leaf, with equal portions on both sides. Very elongate; sides compressed; middle line of dorsum rather sharply keeled. Exuviae central, bright orange-yellow or pale castaneous. Secretionary portion very broad, thin, semi-opaque, dusky white. Length, 2.2 mm.

*Male Puparium*. Similar to that of the female, but much smaller. Larval exuviae central, and orange-yellow in colour.



Fig. 21. *Aspidiotus fiorineides*, Newst., sp. n.; a, lateral view of ♀ puparium on edge of leaf; b, adult ♀; c, terminal portion of body with pygidium; d, pygidium of ♀; e, exuviae ("pellicle") of second stage ♀.

*Female, adult* (fig. 21, b). Narrowly elongate; the length four times as great as the width; extremities narrowed. Dorsum strongly convex; venter flat. Rostrum subcentral. Body, with the exception of the pygidium, densely chitinated; the chitin at the junction with the pygidium appearing deeply divided. The integument of the pygidium membranous, and in several specimens turned backwards, looking as if it were completely invaginated; but when extended (fig. 21, c) it is very long, narrowly rounded, and has no circumgenital glands. Margin of pygidium (fig. 21, d) with three pairs of well developed lobes; median pair largest and notched on both sides; second pair notched on one or both sides; third pair much the smallest. Squamae between the lobes branched; there is also a branched squama just beyond the third lobe and near it two or three simple ones. Anal orifice large, and placed

well forward. Vaginal orifice just below the centre. Parasitised females are sometimes much shorter and broader than what are apparently typical examples; they may also be markedly contorted. Length, 1-1.5 mm.

*Female, second stage.* The exuviae of this stage (fig. 21, *e*) are very strongly arched transversely. Owing to this great convexity it is difficult to determine the exact structural details of the pygidium; the margin of the latter appears however to possess appendages similar to those in the adult; but the three pairs of lobes and the squamae are all relatively much smaller. Length 0.9-1.1 mm.

UGANDA: Jana Isl., Sesse Islands, Lake Victoria, on *Coffea robusta*, 9.x.1918, in association with *Aspidiotus (Selenaspidus) articulatus* var. and *Lecanium subacutum*. Newst. (C. C. Gowdey).

The adult female of this very singular species, in its general facies, bears such a strong resemblance to the second stage females of certain members of the genus *Fiorinia* that I had provisionally placed it in this genus; subsequently embryo larvae were detected within the body of the parent and this at once removed all doubts as to its true generic position. It might also be mistaken for a *Cryptaspidiotus*, but clearly it has no close affinity with this genus. I have found it exceedingly difficult to orientate the females so that the pygidium lies in its normal position; in the majority of cases it either breaks away or lies turned backwards upon the chitinous integument of the abdomen. In the latter case it is exceedingly difficult to detect, and the structural details are rendered almost obscure by the dark chitin of the body wall. Whether the curious, laterally compressed puparium is due altogether to the exigencies of its position on the edge of the leaf remains to be seen. No examples were found on the flat surface; so that it would seem that the creature had, for some unaccountable reason, acquired the remarkable habit of sitting astride the edge in a way which seems to be peculiarly its own, at any rate among the members of the DIASPINAE.

### ***Chionaspis madiunensis*, Zehntner.\***

*Female Puparium.* White, with a fine smooth texture (5 examples), or dusky white and slightly roughened owing to the admixture of the epidermis of the food-plant (1 example). Form moderately convex, circular, broadly ovate, or broadly pyriform. Larval exuviae projecting beyond the margin; translucent white or pale straw-colour. Second exuviae either terminating at the margin or projecting very slightly beyond it; colour pale straw-yellow or brownish-yellow; secretory covering white. Ventral pellicle very thin, white, and attached to the plant. Diameter of large circular form, 3 mm; length of other forms 2.6; width, 2 mm.

*Female, adult* (fig. 22, *a*). Slightly elongate, the length of the body being from two to two and a half times the width of the first free abdominal segment. Mesothorax markedly dilated at the margin proximally; eye placed on a distinct tubercular extension of the margin. Dorsal surface with a number of relatively large chitinised patches or tuberosities. Antennae (fig. 22, *b*) placed closely together immediately above the rostrum; each consisting of a rather long terminal tubercle and a stout outstanding bristle. Mouth-parts placed well forward. All the stigmata (fig. 22, *c*)

\*Meded. Proef. Suiker. Java. (3), No. 6, p. 1 (1898).

with a large group of parastigmatic glands; the first pair placed close up to the mentum; the second pair on the metathoracic segment. The first abdominal segment of the same width as the metathorax; the second much more strongly produced and considerably wider than the two others; third merging into the pygidium. Vaginal orifice a little below the centre of the group of circumgenital glands; anal orifice opposite. Dorsal pores arranged in three well defined but interrupted series. Margin of pygidium (fig. 22, *d*) with four pairs of lobes, all of them very similar in form, but the median pair larger than the rest; second to third pair, inclusive, duplex; the division between each duplex lobe being complete to the base. Squamae simple: there is a short one between each of the lobes, several on the margin



Fig. 22. *Chionaspis madiunensis*, Zehnt., ♀; *a*, adult; *b*, antenna; *c*, stigma; *d*, margin of pygidium; *e*, parasitised ♀.

beyond and also on the two succeeding abdominal segments. The spines are few and not very conspicuous; there are two minute ones between the median lobes, and a slightly longer one at the base of each lobe on the outer margin; a very long one on the dorsal surface in the middle of the first duplex lobe and a smaller one just beyond the fourth lobe. Three conspicuous marginal pores; one between the third and fourth duplex lobes and two beyond the fourth; similar but less conspicuous pairs can be traced on the dorsal surface *over* some of the lobes, especially the fourth pair. In parasitised examples (fig. 22, *e*) the mesothoracic region is not produced laterally, and the free abdominal segments are more pointed.

UGANDA: Kampala, on sugar-cane, 11.ii.1918. (*C. C. Gowdey*).



The deeply divided duplex lobes give the margin of the pygidium a strikingly characteristic appearance. In its general facies the female resembles that of *Chionaspis herbae*, Green;\* but the latter has only three pairs of lobes, whereas *C. madiunensis* has four. There are also other slight differences, notably the large number of chitinised patches on the thorax.

I tender my sincere thanks to Mr. E. Ernest Green for the determination of this species, and also for comparing it with examples of his *C. herbae*. The latter I had not seen.

***Chionaspis tenuidisculus*, sp. nov.**

*Female Puparium.* Form somewhat oblong, sides almost parallel; highly convex, the convexity commencing abruptly near the middle region of the second exuviae. Larval exuviae nude, orange-yellow to golden yellow. Second exuviae bright orange-yellow; secretory covering thin, semitranslucent, white. Secretory portion pure white, slightly polished and very strongly laminate. Length, 1.4-1.7.



Fig. 23. *Chionaspis tenuidisculus*, Newst., sp. n., ♀;  
a, pygidium; b, margin of do.

*Female, adult.* Dead examples dull yellow to red-brown; cuticle rather strongly chitinised; general form fairly well preserved; segmentation distinct; margin folded inwards towards the venter, traces of these folds also visible in the specimens after maceration in KOH. Form elongate, much narrowed and produced anteriorly. Rudimentary antennae rather widely separated; tubercle with one blunt spiny process, and a long and unusually stout spine. Anterior stigmata in a deep horn-shaped cavity; with from one to three gland-pores. Pygidium (fig. 23, a) broadly rounded; median area with several large clear and more or less oval spaces or vacuoles, somewhat irregularly disposed. Anal orifice near the articulation of the abdominal segment. Gland-pores large and rather heavily chitinised. Margin (fig. 23, b) with two pairs of lobes; median pair relatively broad and serrated; second pair duplex, the upper lobule very small and generally notched on both sides. Squamae simple and somewhat slender. Spines minute. Integument rather strongly but finely reticulated.

\*Coccidae of Ceylon, p. 132.

UGANDA: Bukassa Isl., Sesse Islands, Lake Victoria, "on creepers with large fleshy leaf in forest," 10.x.1918 (C. C. Gowdey).

The curious cuticular characters should serve at once to distinguish this species from its allies. The large vacuoles of the pygidium remind one of similar structures found in certain numbers of the genus *Lecanium*; but there are no gland-pores associated with the structures in *Chionaspis tenuidisculus*.

***Chionaspis praelonga*, sp. nov.**

*Female Puparium* (fig. 24, a). Very elongate; the length may be nine to ten times as great as the width; more or less straight or markedly contorted; sides parallel. Colour pure white; texture smooth and slightly polished. Exuviae pale yellowish-brown, ventral pellicle complete. Length, 3-3.7 mm.

*Male Puparium*. Pure white and very faintly tricarinate.

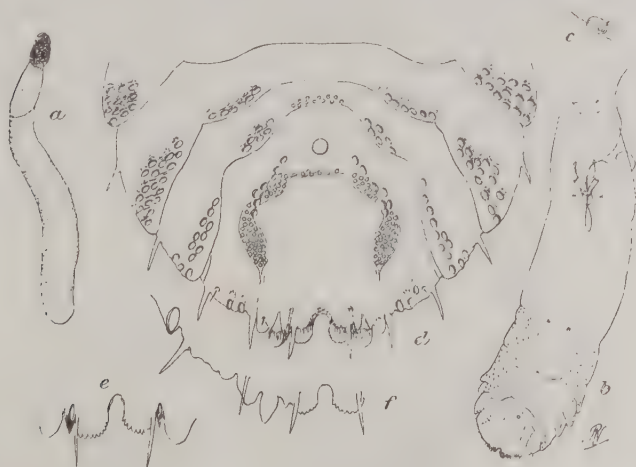


Fig. 24. *Chionaspis praelonga*, Newst., sp. n., ♀; a, puparium; b, ♀; c, antenna; d, pygidium; e, f, portions of margin of pygidium of second stage ♀.

*Female, adult* (fig. 24, b). Very elongate; length about four times as great as the width; cephalic margin slightly narrower than the pygidium. Rudimentary antennae (fig. 24, c) with two long slender spines, one of which is sometimes strongly curved. Parastigmatic glands 4-5, present at the front pair of stigmata only; 2nd pair of stigmata considerably below the middle distance. Pygidium (fig. 24, d) broadly rounded. Median lobes very slightly recessed, edges serrated; second pair of lobes duplex, the inner lobe much the largest, evenly rounded distally, and much more prominent than the median pair. Squamulae slender and spine-like, five on either side of the median lobes. Circumgenital glands in five groups; formula of two examples:

	5		4
9	8	10	8
29	30	29	23

Immediately above the anal orifice, at the junction of the pygidium with the free abdominal segment, is a transverse linear group of 14-15 circular gland-pores of a similar form to those surrounding the genital orifice. The large glandular pores of the dorsum extending as far as the region of the mesothoracic stigmata.

*Female, second stage.* A little more than one-third the length of the adult female; narrowly elongate, sides parallel; cephalic margin slightly narrower than the pygidium. The last-named (fig. 24, *e, f*) with the marginal appendages similar to those in the adult; but the serrations of the median lobes more strongly defined, and the second lobe relatively narrower and longer.

UGANDA: Bufumira Isl., Sesse Islands, Lake Victoria, on an unknown tree, 12.x.1918 (*C. C. Gowdey*).

***Chionaspis auratilis*, sp. nov.**

*Female Puparium.* Moderately elongate; sides generally parallel behind the exuviae; strongly convex, the convexity commencing abruptly in the middle region of the second exuviae. Sides of secretory portion narrowly vertical. Colour pure glistening white, and very finely laminated. Larval exuviae rich dark orange-yellow. Second exuviae dark orange-brown, with the distal portion (pygidium) much paler; secretory covering exceedingly thin, translucent, and present on the anterior half only. Ventral surface open. Length, 1.7-1.8; width, 2.4 mm.

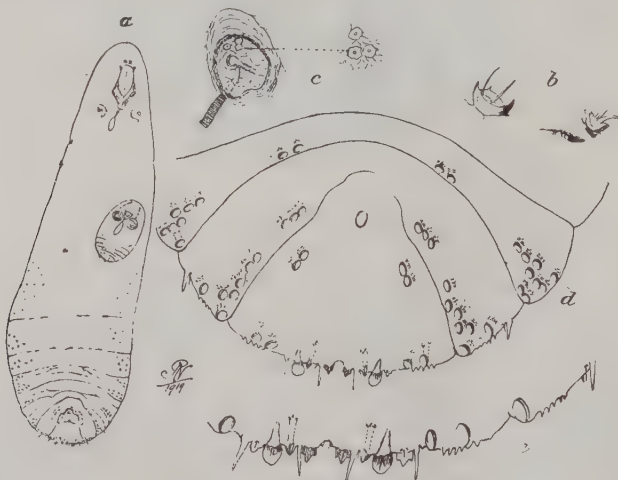


Fig. 25. *Chionaspis auratilis*, Newst., sp. n., ♀; *a*, ♀; *b*, antennae; *c*, anterior stigmata; *d*, pygidium; *e*, margin of pygidium.

*Male Puparium.* Strongly tricarinate. Larval exuviae rich dark orange-yellow, secretory portion of a dull gold colour.

*Female, adult* (fig. 25, *a*). Ovoviviparous. Elongate, gradually narrowed anteriorly; length a little more than three times the greatest width. Rudimentary antennae (fig. 25, *b*) placed very closely together immediately in advance of the rostrum, and furnished with remarkably long spiny processes two of which are

strongly chitinised and longer than the others; and a pair of long slender spines. Anterior stigmata (fig. 25, *c*) with three gland-pores, and surrounded by an exceptionally large peritreme, which latter takes the form of a deep irregular pit, and is surrounded by a well-defined chitinous thickening of the body wall. Pygidium (fig. 25, *d*) broadly rounded. No circumgenital glands. Dorsal gland-pores relatively few in number. Fringe of pygidium (fig. 25, *e*) with two pairs of lobes: median pair much the smaller and strongly tricuspid; second pair somewhat spathuliform, and rather narrowly rounded distally. Margin beyond with several minute pointed tubercles. Squamae simple, three on either side. Spines extremely minute.

UGANDA: Jana Isl., Sesse Islands, Lake Victoria, on an unknown plant. 9.x.1918 (C. C. Gowdey).

This species possesses two strikingly characteristic features: the bright golden colour of the male puparia, and the exceptionally large peritreme or depression to the anterior stigmata. The remarkable form of the antennae of this species bears a close resemblance to that of *Chionaspis coronifera*, Green, but these two species are otherwise easily separable.

### ***Chionaspis dura*, sp. nov.**

*Female Puparium.* Pure white; exuviae nude, and of a dull orange colour. Form elongate; convexity not greater behind the second exuviae than elsewhere; distal portion more or less slightly flattened. Ventral pellicle present at the sides only. Length, 1.7–2.3 mm.

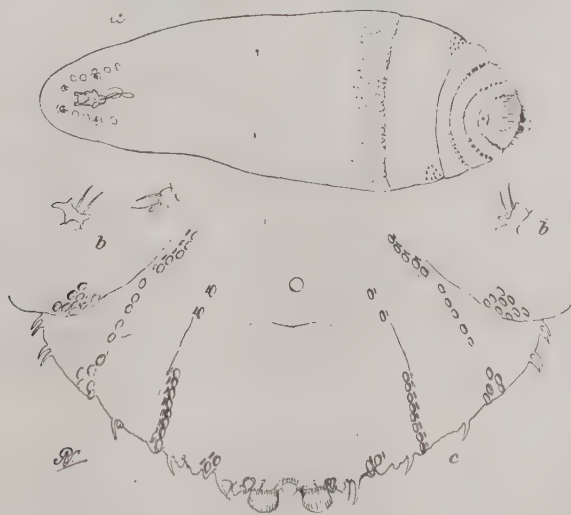


Fig. 26. *Chionaspis dura*, Newst., sp. n., ♀; *a*, ♀; *b*, *b*, antennae; *c*, pygidium.

*Female, adult* (fig. 26, *a*). Colour of dead examples dusky yellow to dull orange. Form very elongate; about two and two-thirds as long as the greatest width; cephalo-thorax, in a line with the proximal portion of the rostrum, about one-half



the width of the first free abdominal segment. A little more than two-thirds of the upper portion of the body more highly chitinised than the rest, this character disappearing after long maceration in KOH. Rudimentary antennae (fig. 26, *b,b*) relatively robust, with two or three blunt spiny processes and a pair of long stout hairs; they are placed midway between the margin and the rostrum. Parastigmatic glands (3-4) present at the anterior spiracles only. Pygidium (fig. 26, *c*) broadly rounded; anal orifice placed well forward and just in advance of the vaginal orifice; margin with a very large pair of slightly divergent median lobes, with the outer edges finely crenulated and longitudinally striate; squamae simple and few in number. Spines minute. No circumgenital glands.

UGANDA: Bufumira Isl., Sesse Islands, Lake Victoria, on an unknown tree 12.x.1918 (*C. C. Gowdey*).

The large divergent lobes, the peculiar form of the antennae and the semi-chitinised upper portion of the body are the distinguishing features of this insect.

### **Chionaspis laniger, sp. nov.**

*Female puparium* (Plate XVI, fig. 2). Somewhat mytiliform, but very highly convex; composed, externally, of white felted woolly material, which when perfect is very strongly and coarsely laminated transversely; beneath the woolly exterior the puparium is hard and shell-like in texture. Ventral scale more or less complete. Exuviae completely covered dorsally with dense loose woolly filaments. Larval exuviae dull yellow; second exuviae dull yellow to pale straw colour. Length, taken from the ventral surface. 2-2.3 mm.

*Female, adult*. Somewhat ovate or more or less deltoid; cephalo-thorax narrowed anteriorly. Rudimentary antennae (fig. 27, *a,a*) with a unilateral spiny projection and two long stout spines, one or both of which may be curved. Parastigmatic glands to both pairs of stigmata: the anterior pair with about ten; the posterior pair with four or five. Dorsal gland-pores on all the segments below the lower pair of stigmata. Pygidium (fig. 27, *b*) gradually rounded. Anal orifice opposite the anterior group of circumgenital glands. Vaginal orifice opposite the space between the two lateral groups of circumgenital glands. The last-named in five groups; the anterior group consisting of about 15; the anterior-laterals of about 30; the lower-laterals of about 60. Margin of pygidium with six or seven dentate lobes on either side; the third and fourth and the fifth and sixth are adjacent and separable only by a narrow line. Squamae simple and very short. Spines small and slender. Length, 1.5-1.9 mm.

*Female, second stage*. Margin of the pygidium with similar dentate lobes to those of the adult, but generally narrower and with the dentations more acute.

*Larva*. Antennae (fig. 27, *c*) of five segments. Just below the cephalic margin, on the dorsal surface, is a pair of relatively large glandular pores (fig. 27, *c*) with very strongly curved cylindrical ducts; the integument surrounding these faintly convoluted. These structures have been observed in the exuviae taken from the puparia.

UGANDA: Kampala, on *Loranthus entebbiensis*, 15.xii.1918 (*C. C. Gowdey*).

This species is remarkable for the unique character of the puparia, which, together with the structural details of the pygidium, should serve as a ready means of determining it.

All the puparia submitted for examination are arranged transversely upon the slender branches of the food-plant; and in one instance there is a double row of them with the cephalic portions (exuviae) of both rows, respectively, meeting together in the middle line.



Fig. 27. *Chionaspis laniger*, Newst., sp. n.; a, a, antennae of ♀; b, pygidium of ♀; c, anterior portion of larval exuviae showing antennae and paired tubular glands.

We tender our congratulations to Mr. Gowdey on his discovery of this extremely interesting addition to the Coccid fauna of Africa.



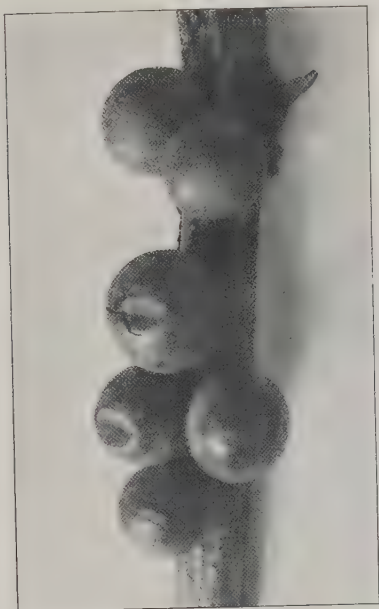


Fig. 1. *Glypeococcus hempeli*, Ckll.,  
adult females,  $\times 2\frac{1}{2}$ .

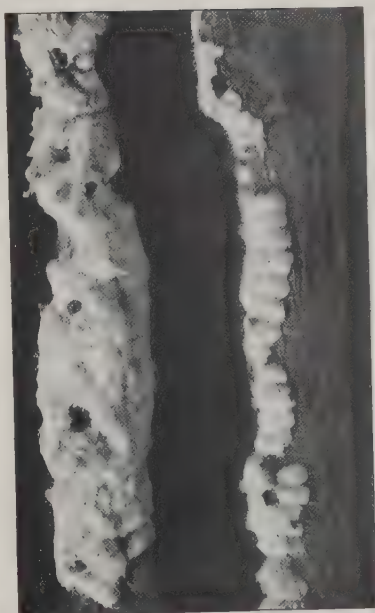


Fig. 2. *Chionaspis laniger*, Newst.,  
puparia of females,  $\times 3$ .



Fig. 3. *Walkeriana digitifrons*, Newst.,  
adult females,  $\times 2$ .



Fig. 4. *Phenacoccus ballardi*, Newst.,  
young and adult females,  $\times 3$ .





## COLLECTIONS RECEIVED.

The following collections were received by the Imperial Bureau of Entomology between 1st April and 30th June, 1919, and the thanks of the Managing Committee are tendered to the contributors for their kind assistance :—

Dr. W. M. Aders, Government Economic Biologist :—13 Culicidae and 38 other Diptera ; from Zanzibar.

Mr. T. J. Anderson, Government Entomologist :—15 Culicidae, 10 *Haematopota*, 1 *Tabanus*, 490 other Diptera, 596 Coleoptera, 10 Planipennia, 4 Isoptera, 189 Rhynchota, 37 Orthoptera, 45 Odonata ; from British East Africa.

Mr. B. N. Bandyopadhyay :—23 Culicidae, 5 other Diptera, and 4 Lepidoptera ; from British East Africa.

Lieut. P. J. Barraud :—2 *Chrysops*, 4 *Tabanus*, 1 Asilid, 6 Hymenoptera, and 19 Coleoptera ; from Macedonia : 842 Culicidae, 36 slides of Culicid larvae, 3 *Chrysops*, 1 *Stomoxys*, 1 Hippoboscid, 116 other Diptera, 24 Hymenoptera, 124 Coleoptera, 5 Planipennia, 50 Lepidoptera, 5 Trichoptera, 6 Isoptera, 50 Anoplura, 9 Rhynchota, 24 Orthoptera, 13 Odonata, 1 Spider, 3 Centipedes, 3 Wood-lice, and 13 Earthworms ; from Mesopotamia.

Mr. G. E. Bodkin, Government Economic Biologist :—8 Diptera, a number of Ants, 13 Chalcids bred from Coccidae, 12 other Hymenoptera, 27 Coleoptera, 4 species of Coccidae, 22 other Rhynchota, 4 Orthoptera, 4 Ticks, 4 Spiders, 2 Centipedes, 6 Millipedes ; from British Guiana.

Mr. J. H. Burkill, Director of the Botanic Gardens :—4 Agromyzid Diptera and 16 larvae and pupae ; from Singapore.

Mr. J. E. A. den Doop :—20 Weevils, with 17 larvae and 21 pupae ; from Java.

Durban Museum :—90 Coleoptera ; from Natal.

The Government Entomologist, Madras :—69 Coleoptera and 6 Rhynchota ; from South India.

Mr. C. C. Gowdey, Government Entomologist :—24 Ticks ; from Uganda.

Mr. E. Hargreaves :—146 Culicidae, 1 *Pangonia*, 3 *Chrysops*, 1 *Haematopota*, 11 *Tabanus*, 25 other Diptera, 39 Hymenoptera, 110 Coleoptera, and 3 Orthoptera ; from Taranto, Italy.

The Imperial Entomologist, Pusa :—3 Stephanidae ; from India.

Imperial Institute :—9 silk cocoons damaged by *Anthrenus* ; from Morocco.

Mr. S. Leefmans, Instituut voor Plantenziekten, Buitenzorg :—35 Coleoptera and 58 Rhynchota ; from Java.

Mr. F. Muir :—5 Weevils and 2 larvae, and 29 Delphacidae.

Prof. G. H. F. Nuttall, F.R.S. :—59 Coleoptera, from Burma : and 44 Culicidae, 7 Ceratopogoninae, and 38 other Diptera ; from British East Africa.

Mr. W. H. Patterson :—10 Coleoptera and 2 larvae ; from the Gold Coast.

Mr. R. Swainson-Hall :—2 Coleoptera ; from Portuguese Congo.

Mr. R. Veitch, Entomologist, Colonial Sugar Refining Company :—9 Diptera, 25 Hymenoptera, 9 Coleoptera, 1 Lepidopteron, and 14 Rhynchota ; from Fiji.

Dr. W. G. Watt, Medical Officer of Health :—195 Culicidae and 107 larvae ; from the Gold Coast.

Mr. C. B. Williams :—12 Diptera, 616 Ants, 3 Moths, 306 Rhynchota, 3 Thrips, 1 Centipede, and 1 Spider ; from Trinidad.

Mr. Rodney C. Wood :—9 *Tabanus*, 45 other Diptera, 101 Coleoptera, and 3 Rhynchota ; from Nyasaland.

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# NOTES ON THE ETHIOPIAN FRUIT-FLIES OF THE FAMILY TRYPANEIDAE, OTHER THAN DACUS.—III.\*

By Prof. M. BEZZI,

*Turin, Italy.*

(PLATES XVII-XVIII.)

The new material received from the Imperial Bureau of Entomology through the kindness of the Director, Dr. G. A. K. Marshall, enables me to prepare this third paper on the Ethiopian fruit-flies. It is a proof of the great richness of the African Trypaneid fauna that of over 41 species received only 10 were referable to previously described species, and that no less than 8 new genera have been erected, most of them for very strikingly characterised forms.

\* \* \* \* \*

The TRYPANEIDAE at present known from the Ethiopian Region, with the addition of the new forms here described for the first time, are enumerated in the following systematic catalogue, which numbers 216 species.

## I. Subfamily DACINAE.

### 1. TRIDACUS, Bezzi.

lounsburyi, Coq.  
sphaeristicus, Speis.  
fuscovittatus, Grah.  
armatus, F.  
fuscatus, Wied.  
nebulosus, Walk.  
d'emmerezi, Bezzi.  
bivittatus, Big. (*pectoralis*, Walk.;  
*bipartitus*, Grah.; *cucumarius*, Sack;  
*armatus*, Bezzi).  
momordicae, Bezzi (*bipartitus*, Bezzi).  
eburneus, Bezzi.  
xanthopterus, Bezzi.  
humeralis, Bezzi.  
disjunctus, Bezzi.  
flavicus, Grah.  
scaber, Loew.  
stylifer, Bezzi.  
punctatifrons, Karsch.

### 2. DACUS, F.

hamatus, Bezzi.  
trigonus, Bezzi.  
inornatus, Bezzi (*modestus*, Bezzi).

oleae, Gmel.  
mesomelas, Bezzi.  
semisphaereus, Beck.  
blepharogaster, Bezzi.  
rufus, Bezzi.  
annulatus, Beck.  
erythraeus, Bezzi.  
mochii, Bezzi.  
woodi, Bezzi.  
macer, Bezzi.  
immaculatus, Coq.  
brevis, Coq.  
ficicola, Bezzi.  
bistrigulatus, Bezzi.  
brevistriga, Walk.  
brevistylus, Bezzi.  
vertebratus, Bezzi.  
binotatus, Loew.  
bistrigatus, Loew.  
ciliatus, Loew.  
sigmoides, Coq.  
africanus, Adams.  
sexmaculatus, Walk.  
longistylus, Wied. (*testaceus*, Macq.;  
*kingi*, Frogg.).

## II. Subfamily ADRAMINAE.

### 3. MERACANTHOMYIA, Hendel.

antennata, Hend.

### 4. SOSIOPSILA, Bezzi.

trisetosa, Bezzi.

\* For Part I, see Bull. Ent. Res. viii, pp. 215-251; for Part II, *ibidem* ix, pp. 13-46.  
(637) Wt.P4/140. 1,000. 3.20. B.&F.Ltd. G.11/4. ▲



## III. Subfamily CERATITINAE.

5. *COELOPACIDIA*, End.  
strigata, Bezzi.  
melanostigma, Bezzi.  
madagascariensis, End.

6. *CONRADTINA*, End.  
longicornis, End.  
acrodiauges, Speis.  
acroleuca, Wied.  
suspensa, Bezzi.

7. *CELIDODACUS*, Hendel.  
obnubilus, Karsch (*apicalis*, Hend.).  
coloniarum, Speis.

8. *CARPOPHTHOROMYIA*, Austen.  
vittata, F.  
scutellata, Walk.  
tritea, Walk.  
pseudotritya, Bezzi.  
superba, Bezzi.

9. *LEUCOTAENIELLA*, Bezzi.  
guttipennis, Bezzi.  
trispila, Bezzi.  
pentaspila, Bezzi.

10. *CHELYOPHORA*, Rondani.  
magniceps, Bezzi.

11. *BISTRISPINARIA*, Speiser.  
fortis, Speis.

12. *CLINOTAENIA*, Bezzi.  
grata, Wied.  
anastrephina, Bezzi.

13. *CERATITIS*, McLeay.  
capitata, Wied.  
catoirii, Guér.

14. *PTERANDRUS*, Bezzi.  
anonae, Grah. (*pennipes*, Bezzi).  
colae, Silv.  
rosa, Karsch.  
fasciventris, Bezzi.  
rubivorus, Coq.  
volucris, Bezzi.  
? penicillatus, Big.

15. *PARDALASPIS*, Bezzi.  
morstatti, Bezzi.  
punctata, Wied.  
brêmei, Guér.  
melanaspis, Bezzi.  
cosyra, Walk. (*giffardi*, Bezzi).  
silvestrii, Bezzi.  
senegalensis, Macq.  
antistictica, Bezzi.  
flexuosa, Walk.  
quinaria, Bezzi.  
stictica, Bezzi.  
aliena, Bezzi.

16. *PERILAMPIS*, Bezzi.  
pulchella, Austen.  
formosula, Austen.

17. *HOPLOLOPHA*,<sup>1</sup>Bezzi.  
cristata, Bezzi.

18. *TRIRHITHRUM*, Bezzi.  
lycii, Coq.  
nitidum, v. Röd.  
albonigrum, End.  
validum, Bezzi.  
nigrum, Grah. (*obscurum*, End.).  
gagatinum, Bezzi.  
occipitale, Bezzi.  
bimaculatum, v. Röd.  
nigerrimum, Bezzi.  
leucopsis, Bezzi.  
inscriptum, Grah. (*coffae*, Bezzi).  
? albomaculatum, v. Röd.

19. *XANTHORRHACHISTA*, Hendel.  
alata, Beck. (*cephala* Hend.).

20. *THEMARICTERA*, Hendel.  
flaveolata, F.  
rufipennis, Hend.  
laticeps, Loew.

21. *THEMARA*, Walker.  
fallacivena, End.

22. *BARYGLOSSA*, Bezzi.\*  
histrio, Bezzi.

23. *PTILONIOLA*, Hendel.  
neavei, Bezzi.  
preussi, Hend.  
tripunctulata, Karsch.  
(Nov. GENUS.)  
guttatolimbata, End.

24. *RHACOCOLAENA*, Loew..  
fasciolata, Loew.  
pulchella, Bezzi.  
hammersteini, End.

25. *PHORELLIA*, R. Desv.  
brunithorax, R. D.  
tristriata, Karsch.

26. *TAOMYIA*, Bezzi.  
marshalli, Bezzi.  
ocellata, Lamb.

27. *NOTOMMA*, Bezzi.  
bioculatum, Bezzi.  
(Nov. GENUS.)  
jucunda, Loew.

28. *ACIDIA*, R. Desv.  
seychellensis, Lamb.  
fossataeformis, Bezzi.  
homogenea, Bezzi.

29. "OCNEROS," O. G. Costa.  
mundus, Loew.  
excellens, Loew.  
sinuatus, Loew.  
undatus, Bezzi.  
bigemmatum, Bezzi.

\* The genus *Cladoderis*, Bezzi, is better placed in the ORTALIDAE, and will be dealt with in a forthcoming paper on this family.

III. Subfamily CERATITINAE.—*cont.*

30. OCNERIOXA, Speiser.  
pennata, Speis.  
woodi, Bezzi.  
discreta, Bezzi.  
gracilis, Loew.

31. TEPHRITIS, Latr.  
indecora, Loew.  
vernonicola, Bezzi.

32. CARPOMYIA, A. Costa.  
incompleta, Beck.

33. CRASPEXOXANTHA, Bezzi.  
marginalis, Wied.  
manengubae, Speis.

34. TERELLIA, R. Desvoidy.  
? hysia, Walk.

35. ALLOTRYPES, Bezzi.  
brevicornis, Bezzi.

36. ACTURA, R. Desv.  
perspicillaris, Bezzi.  
angusta, Loew.  
semiangusta, Bezzi.  
\*caeca, Bezzi.  
oborinia, Walk.  
tetrachaeta, Bezzi.  
capensis, Rond.  
ternaria, Loew.  
binaria, Loew.

37. SPHENISCOMYIA, Bezzi.  
sexmaculata, Macq.  
neavei, Bezzi.

38. TEPHRELLA, Bezzi.  
bezziana, End.  
nigricosta, Bezzi.  
cyclopica, Bezzi (*w-fuscum*, End.).  
tephronota, Bezzi.  
rufiventris, Bezzi.  
sexfissata, Beck.  
hessii, Wied.

IV. Subfamily TRYPANEINAE.

39. PLATENSINA, Enderlein.  
diaphasis, Big.

(NOV. GENUS).  
lunifera, Loew.

40. EUTRETOSOMA, Hendel.  
oculatum, Hend.  
frauenfeldi, Schin.  
bipunctatum, Loew.  
millepunctatum, Bezzi.  
polygramma, Walk.

41. ELAPHROMYIA, Bigot.  
adatha, Walk. (*melas*, Big. ; *ulula*, Loew).

42. SPATHULINA, Rondani.  
semitra, Loew.  
bioculata, Bezzi.  
parceguttata, Beck.  
acrosticta, Bezzi.  
aldabrensis, Lamb.  
margaritifera, Bezzi.

43. PLIOMELAENA, Bezzi.  
brevifrons, Bezzi.  
strictifrons, Bezzi.

44. EUARESTA, Loew.  
planifrons, Loew.  
amplifrons, Bezzi.

45. ENSINA, R. Desv.  
sororecula, Wied.  
gladiatrix, Bezzi.  
myiopsitoides, Bezzi.  
anceps, Loew.  
magnipalpis, Bezzi.  
dubia, Walk.

ignobilis, Loew.  
siphonina, Bezzi.

46. EURIBIA, Meigen.  
perpallida, Bezzi.  
discipulchra, Bezzi.  
praetexta, Loew.  
cafra, Loew.  
dissoluta, Loew.  
tristrigata, Bezzi.  
cyana, Walk.

47. CAMPIGLOSSA, Rondani.  
perspicillata, Bezzi.

48. CAMAROMYIA, Hendel.  
acrophthalma, Bezzi.  
? helva, Loew.

49. ACANTHIOPHILUS, Becker.  
helianthi, Rossi.  
? ochraceus, Loew.

50. TRYPANEA, Schrank.  
subcompleta, Bezzi.  
hemimelaena, Bezzi.  
peregrina, Adams (*urophora*, Bezzi).  
augur, Frauenf.  
tristricula, Hend. \*  
auguralis, Bezzi.  
hexapoda, Bezzi.  
confluens, Wied.  
aucta, Bezzi.  
repleta, Bezzi.  
aira, Walk.  
amoena, Frauenf.  
decora, Loew.  
diversa, Wied.

\* This recently described species was erroneously included by Prof. Hendel in his great work on the South American Trypaneids, 1914, p. 82 ; but it is from Mozambique, and was accidentally omitted by me in my previous paper ; it is very near *augur*, has about the same wing pattern, and has likewise only two scutellar bristles.

## V. Subfamily SCHISTOPTERINAE.

51. *PERIRHITHRUM*, Bezzi.  
marshalli, Bezzi.52. *RHABDOCHAETA*, de Meijere.  
spinosa, Lamb.  
neavei, Bezzi.53. *RHOCHMOPTERUM*, Speiser.  
neuropteripenne, Speis.54. *SCHISTOPTERUM*, Becker.  
moebiusi, Beck.

\* \* \* \* \*

The addition of the very interesting new genus which follows makes necessary a modification of the beginning of the table of genera in my first paper, p. 216, nos. 1-5, which may be modified as follows:—

1(6). Thoracic chaetotaxy incomplete, *hm.*, *prst.*, *dc.* and *st.* being always wanting (and also the *prsc.* in African forms).

a(d). Arista bare; abdomen short and broad, usually broader than the thorax; wings with the first three longitudinal veins closely approximated, the anterior cross-vein long and oblique, the second basal cell dilated and the anal cell drawn out into a very long point .. Subfam. DACINAE.

b(c). Only two *sa.* present, the anterior one being entirely wanting  
*Dacus*, F. (*s. str.*).

c(b). Three *sa.*, the anterior one being well developed .. *Tridacus*, Bezzi.

d(a). Arista plumose; abdomen long and linear, more narrow than the thorax; wings with the first three veins not approximated, the anterior cross-vein short and placed perpendicularly, the second basal cell not dilated and the anal cell with a short point .. .. Subfam. ADRAMINAE.

e(f). Femora not spinose beneath; thoracic suture interrupted in the middle; antennae shorter than the face; point of the anal cell very short

*Sosiopsila*, gen. nov.

f(e). Femora spinose beneath; thoracic suture complete; antennae much longer than the face; point of the anal cell longer .. *Meracanthomyia*, Hend.

## II. Subfam. ADRAMINAE.

The present subfamily is here accepted in a wider sense than that attributed to it by Hendel in 1914, and corresponding to that adopted by me in 1916.\* The subfamily was believed to be almost exclusively Oriental; but the discovery of the following new form shows that it is probably well represented in the Ethiopian Region also.

*Sosiopsila*, gen. nov.

The present new genus seems to be allied to the Oriental *Neosophira*, Hendel (Gen. Insect., 76, pl. iii, figs. 57-59 and 64) and to *Colobostroter*, Enderlein (Zool. Jahrb., xxxi, p. 445, fig. T.), but is distinct in having well developed outer *vt.*, and also in having only a pair of *sc.* (the basal pair); on the wings the third longitudinal vein is not sinuous.

Head in front view more broad than high, a little broader than the thorax; occiput convex and prominent, with developed lower swellings; the head is attached to the thorax about in the same manner as described for the genus *Xanthorrhachista*.

\* Bull. Ent. Res., vii, October 1916, p. 120.

Eyes oval, less compressed, their vertical diameter being only a little longer than the horizontal one. Frons flat, not at all prominent in profile, with parallel sides, only a little longer than broad; lunula narrow, but much extended laterally; face flat in the middle, with shallow antennal grooves and with distinctly prominent mouth-border. Cheeks linear; jowls not broader than the breadth of the third antennal joint. Antennae inserted at the middle of the eyes, only a little shorter than the face; third joint pubescent, rounded at tip; arista plumose, its feathering being about as broad as the length of the third antennal joint. Proboscis short and thick, with very broad flaps, which cover the palpi. Cephalic chaetotaxy rather developed, only the *oc.*, *pvt.* and genal bristles being wanting; no *ocp.*; outer *vt.* half as long as the strong inner pair; one strong *s. or.*, and two pairs of long and distant *i. or.* Thorax elongate, with incomplete suture and reduced chaetotaxy; there are only two *npl.*, one *a.*, and two *p. sa.*, one *mpl.*, one *pt.*; the *scp.* are rudimentary, only the middle pair being distinct. Scutellum triangular, flat above, a little broader than long, distinctly carinate on the sides, with only the *b. sct.*, which are very long, strong and diverging. Abdomen narrow and long, of cylindrical shape, narrow at base but not properly pedunculate, in the male with 4, in the female with 5 segments; the last two segments bear some strong bristles at the sides behind. Male genitalia small and rounded; ovipositor short, depressed, with the basal segment as long and nearly as broad as the terminal segment of the abdomen, and with the apical segment much narrower and acute. Legs long and simple, with non-spinose femora, even the front pair being without bristles below; middle femora elongate, as long as their tibiae, and a little thickened; middle tibiae with a single long spur at end; hind tibiae shorter than their femora, distinctly curved, with scattered bristles on the outer side; claws very short. Wings short and proportionally narrow, hyaline, with a broad black spot at apex. Costa densely ciliate, with no distinct bristle; auxiliary vein closely approximate to the first longitudinal vein, which ends at middle of the fore border, before the small cross-vein, and is pilose above. Second longitudinal vein straight; third bristly throughout its whole length and slightly curved but not sinuous; last segment of the fourth vein slightly diverging at end; small cross-vein a little beyond the middle; hind cross-vein straight and perpendicular,  $2\frac{1}{2}$  times as long as the small one; anal cell a little broader than the second basal cell, its inferior angle acute but not produced and shorter than the upper one; sixth vein reaching the hind border. Axillary lobe equal in the two sexes; alula longer than broad.

Type: the following new species:—

**Sosiopsila trisetosa**, sp. nov. (Pl. xvii, fig. 1).

A narrow and elongate, entirely yellow species not unlike a *Psila*, with a broad rounded black spot on the mesophragma, and with a broad black spot near the apex of the wing.

♂♀. Length of body, 6·5–7 mm.; of wing, 4·5–5 mm.; of ovipositor, 0·7 mm.

Head and its appendages completely yellow. Occiput shining, unspotted; frons more yellow, dull and finely pubescent in the middle, but with shining ocellar and vertical plates, the ocellar not being reddish brown, like the upper border of the lunula. Face shining in the centre; cheeks and jowls with a faint whitish dust,



like the lower occipital swellings. All the cephalic bristles are yellowish, only the *vt.* and the *s. or.* being a little darker. Thorax entirely yellow; darker, less shining and punctulate on the dorsum, lighter, more shining and smooth on the pleurae; the very short and scattered pubescence of the dorsum is yellowish, like all the macrochaetae, only the *p. sa.* being darkened, chiefly the interior one; the pleurae have only sparse and very thin pale yellowish hairs on hind border of meso- and on upper border of sternopleura. The scutellum is coloured like the mesonotum and shining; it bears some pale yellowish hairs, while its macrochaetae are black. The mesophragma is shining yellow, but it has in the middle a broad, rounded, shining black spot, which is prolonged above in the middle of the postscutellum. Halteres and squamulae pale yellowish, the latter with a pale fringe. Abdomen shining yellow like the mesonotum and similarly punctate, with longer and denser pale yellowish pubescence; its terminal macrochaetae are black; venter yellow. Male genitalia shining yellow and yellowish pubescent; the ovipositor likewise. Legs entirely yellow, with pale pubescence and pale hairs, only the spurs of the middle tibiae being black; the middle femora have below in the middle three rigid long hairs, directed downwards, stronger and more bristly in the male than in the female. Wings quite hyaline and strongly iridescent; the veins are yellow, with blackened ends, but the whole costa (with its ciliation) is black; the costal cell is yellowish, and the short and narrow stigma dark yellow. The black apical spot is attached to the costa by its base, which extends from the end of the second to the end of the third vein; it is continued inwardly, crossing the third vein and ending roundly on the fourth vein; the end of the first posterior cell is therefore completely hyaline, while the end of the submarginal cell is broadly black. In the female the apical spot extends only to the middle of the first posterior cell, without reaching the fourth vein; but even in the male the part of the spot placed beyond the cubital fold is lighter.

Type ♂ and type ♀, a single pair of specimens from Portuguese East Africa, E. of Mt. Mlanje, 21-23, xi., 1913 (*S. A. Neave*); an additional female specimen from Nyasaland, Mt. Mlanje, 8.x.1913 (*S. A. Neave*).

### III. Subfam. CERATITINAE.

In the new material are present some very important species, which belong to the two genera *Coelopacidia* and *Celidodacus*, previously unknown to me; they may be comprised in my table of the genera on p. 216, just after no. 8 (67), as follows:—

- A(B). *Prst.*, *dc.* and *st.* wanting; face very concave in the middle; arista bare; femora not spinose beneath; third longitudinal vein bristly throughout its whole length . . . . . *Coelopacidia*, End.
- B(A). The above-named bristles present, or at least not all wanting at the same time; face flat or even convex in the middle.
- 9(10). Femora spinose beneath; arista shortly plumose; third longitudinal vein with only a few bristles near its extreme base.
- a(b). Wings very broad, with the second and third longitudinal veins sinuous, the last portion of the third being moreover bent downwards at the end. *Conradina*, End.
- b(a). Wings narrower, with the above-named veins not sinuous and with the last portion of the third straight . . . . . *Celidodacus*, Hend.

**Coelopacidia**, Enderlein, 1911.

This genus was placed by its author near *Acidia*, while in Prof. Hendel's table it comes near *Platyparea*. I have before me two species, which agree in the form of the body and head, and in the reduced wing pattern, with the description of Dr. Enderlein; but the author has not described the chaetotaxy, which is very reduced in the species before me.

The systematic position of the genus is dubious. In the want of *prst.*, *dc.*, *prsc.* and *st.* it agrees with the DACINAE and ADAMINAE, but differs from them in the presence of the *hm.* Owing to this last character, the presence of distinct *ocp.* and to the presence of bristles on the underside of the front femora, I prefer to locate the genus at the beginning of the CERATITINAE, as a connecting link between this subfamily and the ADAMINAE.

I have not seen the genotype, *C. madagascariensis*, End., but I will give here a characterisation of the genus drawn from the two continental species at hand.

Head in front view about as broad as high, not broader than the thorax; occiput convex and prominent, with developed but not sharply differentiated lower swellings; neck inserted just below the middle of the occiput, which bears a tubercle above it. Frons distinctly concave in the middle, parallel-sided, about twice as long as broad; lunula very narrow and not extended at sides. In profile the eyes are much rounded, their vertical diameter being only a little longer than the horizontal one; they are higher above than the middle of the hollowed frons, while in front the frons is prominent as a distinct conical protuberance, which bears the antennae. Face deeply hollowed in the middle, without median keel and with undifferentiated antennal grooves, but distinctly prominent below at the mouth-border; cheeks linear; jowls as broad as the breadth of the third antennal joint. Antennae inserted at middle of the eyes; in consequence of the protuberance of the fore part of the frons and of the excavation of the face, they are rather porrect; third joint rounded at tip, bare, not reaching the mouth; arista long, thin, with very short scattered pubescence. Proboscis short and thick; palpi less clavate and shortly setulose. Cephalic chaetotaxy reduced; *ocp.* reduced to some thin acute yellowish bristles; *prst.* very short, thin, almost indistinct; no *oc.*; four *vt.*, the inner pair not much longer than the outer one; one *s. or.*, erect and directed backwards, placed near the middle of the frons, at the front end of the long narrow curved ill-differentiated vertical plates; one *i. or.* just above the lunula, directed inwards and decussate; genal bristle thin and short. Thorax elongate, with the suture narrowly interrupted in the middle; *scp.* long and strong, those of the middle pair approximate; two *npl.*; one *a. sa.* and two *p. sa.*; one *mpl.*; no distinct *pt.* and no *st.* Scutellum flat, triangular, as long as broad, with lateral keels and with two pairs of strong bristles, the apical ones parallel and not much weaker. Abdomen elongate, narrower than the thorax, of linear shape, being as broad at end as at base; there are 4 segments in the male and 5 in the female, but the sutures are not very distinct; last segment with some macrochaetae at hind border in both sexes; male genitalia rounded and concealed; ovipositor with the basal segment depressed, triangular, obtuse, as long as the last two abdominal segments together; apical segment narrow, acute. Legs slender; front femora with only one bristle below near the end, middle femora distinctly thickened, shorter than their tibiae, which bear two equally strong spurs

at the end; hind tibiae straight, shorter than the femora, with some short bristles on outer side; claws short. Wings long, hyaline, with a very small apical black spot. Costa not ciliated, shortly pilose, without bristle; auxiliary vein closely approximated to the first vein, which is pilose and ends before or opposite to the small cross-vein; second and third vein straight and diverging at their ends, the third bristly throughout; small cross-vein beyond the middle of the discoidal cell; hind cross-vein straight and perpendicular; last segments of the third and fourth veins parallel; second basal cell not dilated, but very long; sixth vein produced to the hind border; anal cell not broader than the second basal cell, its lower angle drawn out into a point which is rather long, but is always shorter than the second basal cell; axillary lobe equal in the two sexes; alula longer than broad.

The known species may be distinguished as follows:—

- 1(2). Front femora with some bristles below near the end; wings without black apical spot, but with a dark border to the hind cross-vein  
*madagascariensis*, End.
- 2(1). Front femora with only one bristle below; wings with a black apical spot, but the hind cross-vein not or less infuscated.
- 3(4). Thorax on the dorsum with a whitish pollinose, longitudinal, middle stripe; wings with yellow stigma and with a slightly infuscated hind cross-vein  
*strigata*, sp. nov.
- 4(3). Thorax not striped; wings with black stigma and the hind cross-vein not infuscated .. .. .  
*melanostigma*, sp. nov.

#### ***Coelopacidia strigata*, sp. nov.**

An elongate, entirely yellow species, distinguished by the whitish thoracic stripe and the yellow pterostigma.

♂ ♀. Length of body 9·9–5 mm.; of ovipositor 1 mm.; of wing 8·8–5 mm.

Head entirely yellow, unspotted, only the very small ocellar dot being black. Occiput very shining and bare, except for a few short hairs near the neck and on the lower part; frons wholly glistening, quite bare, with the front part slightly reddish above the lunula, the upper border of which is narrowly brown. Face very glistening; cheeks and jowls not pruinose. Antennae entirely yellow, even on the apical part of the last joint; second joint short and nearly bare; third joint about twice as long as broad; arista yellowish. Palpi pale yellowish; proboscis dirty reddish, with pale hairs. Of the cephalic bristles the two pairs of *vt.* and the *s. or.* are black, the thin *pvt.* and the *ocp.* are yellowish, like the *i. or.* and the genal bristle; the sparse and short hairs of the lower part of the occiput are pale yellowish. Thorax entirely yellow and shining; but the dorsum, being punctulate, is less shining than the very glistening pleurae, which are moreover of a paler colour; the whitish pollinose middle stripe is broad, but only distinct when the thorax is viewed from in front; this stripe begins just beyond the middle *scp.* and ends before reaching the scutellum broadening gradually behind. The very short and sparse pubescence of the dorsum is pale yellow, while the pleurae are quite bare, with only a few, hardly visible, thin and whitish hairs on the mesopleura. Scutellum entirely glistening yellow, bare, with some scattered pale hairs at the hind border. All the macrochaetae of the thorax and scutellum are black. Postscutellum and



mesophragma shining yellow, the latter more or less reddish in middle or on upper border. Squamulae very small, with sparse and short pale hairs at border; halteres pale yellowish, with more reddish knob. Abdomen entirely shining yellow; but there is a narrow dark longitudinal stripe along the middle of the two basal segments, rather faintly marked; the pubescence is more dense than that of the thorax, but is always short and yellowish; the apical macrochaetae are black. The venter is shining yellow in the middle, whitish dusted on the sides. Male genitalia shining yellow, with pale pubescence; ovipositor shining yellow, with very short and sparse pubescence. Legs entirely shining yellow, with more reddish tarsi; their sparse pubescence is pale, but the bristles of the femora and tibiae are black, like the apical spurs of the middle tibiae; the middle tibiae have a longitudinal row of three rather strong black bristles towards the middle of the posterior side; the hind tarsi are ciliated below, chiefly on the praetarsi; the claws are black, the pulvilli whitish. Wings yellowish-hyaline, very shining and iridescent; costa and veins yellowish, but the thickened basal part of the first longitudinal and the common stem of the second and third, are black; the cross-veins and the ends of the longitudinal veins are blackish; the stigma is entirely yellow. The apical dark spot is small, extending symmetrically on both sides of the end of the third longitudinal vein, along the wing border; it is broader in the female than in the male. The infuscation of the hind cross-vein is very small and faintly indicated, sometimes even indistinct. The first longitudinal vein ends in the costa a little, but distinctly, before the small cross-vein.

Type ♂ and type ♀, a couple of specimens from Nyasaland, Limbe, Chiromo, Ruo R., 22.ix.1916 (*R. C. Wood*).

### ***Coelopacidia melanostigma*, sp. nov.**

Closely allied to the preceding species, but differing in some particulars of the coloration and in the longer third antennal joint.

♂. Length of body 8.5 mm.; of wing 7.5 mm. Head and its appendages exactly as in *C. strigata*, but the *pvt.* more developed and blackish; the third antennal joint is distinctly longer and reaches the mouth-border, being about 2.5 times as long as broad. Thorax, scutellum and halteres as in the preceding species, but there is no trace of the whitish middle stripe; there is moreover a small but distinct *pt.*, which is not to be seen in *C. strigata*. Abdomen the same, with the basal stripe blacker and more sharply defined. The wings likewise, but the stigma is entirely of a deep black colour; the first longitudinal vein ends opposite to the small cross-vein, not before it; the apical dark spot is similarly shaped, but there is no trace of the infuscation of the hind cross-vein. The legs are identical.

Type ♂, a single specimen caught in the same locality and on the same day as the specimens of *C. strigata*, from which it is certainly distinct (*R. C. Wood*).

### ***Conradtina acrodiauges*, Speiser, 1913 (Pl. xvii, fig. 2.)**

A couple of specimens of this characteristic fly from S. <sup>1</sup>/<sub>2</sub> Nigeria, Ibadan, 29.xi.1913—20.i.1914 (*Dr. W. A. Lamborn*).



**Celidodacus**, Hendel, 1914.

Prof. Hendel has differentiated the present genus from *Conradina* only on account of the wing pattern; the chaetotaxy of the head and thorax seems to be the same in both genera; but I think that the form of the wings and the shape of the second and third longitudinal veins can be regarded as sufficient for generic separation.

I have before me what I believe to be the genotype, named *apicalis*, but not described, by Prof. Hendel; I think that it is the same as *Acidia obnubila* of Karsch, even though the latter author does not mention the spines on the underside of the femora. A close ally of this species seems to be *Acidia coloniarum*, Speiser, which has a different wing pattern, having an isolated dark band across the small cross-vein.

I will give here a characterisation of the genus *Celidodacus*, with some additional notes on the type-species.

Head in front view distinctly broader than high. Occiput rather flat above and less prominent below, the lower swellings being not developed. Eyes rounded, with the vertical diameter longer than the horizontal one. Frons flat, parallel-sided, 1.5 times longer than broad; in profile it is only a little prominent above the root of the antennae; lunula very small. Face convex in the middle, with broad antennal grooves; mouth-border prominent; cheeks linear; jowls narrow. Antennae inserted a little above the middle of the eyes, with the third joint acute but rounded at tip, long, extending a little beyond the mouth-border; arista plumose, the breadth of the feathering being equal to the breadth of the third antennal joint towards the middle. Proboscis short and thick; palpi broad and bristly. Cephalic bristles strongly developed; *ocp.* acute and black; two *vt.*, the inner pair longer; *pvt.* well developed; no *oc.*; two *s. or.* and three *i. or.*; genal bristle well developed; there is also a bristle towards the middle of the lower part of the occiput. Thorax broad and stout, with complete and strongly developed chaetotaxy; *scp.* long, those of the middle pair not approximated; the *dc.* pair is placed much behind; two *mpl.*; *pt.* strong. Scutellum triangular, as long as broad, flat above, with lateral keels and four long strong bristles. Abdomen with 4 segments in the male and 5 in the female, narrowed at base, about as broad as the thorax in the middle, with terminal bristles; male genitalia small; ovipositor short and broad, depressed. Legs short and stout, all the femora spinose beneath, but those of the hind pair less so than the others; middle femora thickened; middle tibiae with a single spur at the end; hind tibiae with less developed posterior row of bristles. Wings proportionately narrow, with well developed pattern. Costa not ciliated and without bristle; auxiliary vein stout and well separated; first longitudinal vein ending before the middle of the costa and before the small cross-vein; second vein a little sinuous; third bristly throughout, straight on its last portion and diverging from the fourth; small cross-vein much beyond the middle, placed on the last third of the discoidal cell; hind cross-vein straight; sixth vein reaching the hind border; point of the anal cell acute, as long as the second basal cell; axillary lobe broad; alula rounded.

**Celidodacus obnubilis**, Karsch, 1887; (*apicalis*, Hend., 1914). (Pl. xvii, fig. 4).

A robust species, at once distinguished an account of the peculiar coloration, of the thorax and wings.

♂♀. Length of body 7.5–8 mm.; of ovipositor 1 mm.; of wing 6.5–7 mm.

Head entirely reddish yellow, only the small ocellar dot being black; frons opaque and with scattered hairs in the middle, shining at vertex and on vertical plates; antennae entirely yellowish, with the third joint three times as long as broad; palpi and proboscis yellowish. All the cephalic bristles are black. The rather opaque thorax has in the middle of the dorsum two broad longitudinal stripes of whitish dust, which are visible only in certain lights; on their outer border there is on each side a small black stripe, which is sometimes wanting; the middle brown stripe, as described by Karsch, is formed only by the space between the two whitish stripes. Very characteristic is the white, black-margined stripe on the notopleural line. All the bristles are black, and the short pubescence of the dorsum is likewise black. Scutellum like the mesonotum, with short and sparse pubescence on the sides. Pleurae shining, with soft thin pubescence. Squamulae and halteres whitish. Mesophragma and postscutellum shining black, but sometimes reddish or yellowish. Abdomen above either entirely shining black, or with the first two segments more or less broadly yellowish; the pubescence is blackish, the bristles black. Male genitalia shining black, ovipositor shining black, sometimes reddish brown towards the middle. Legs entirely yellow, with black bristles, spines and spurs; front femora with two rows of 5–6 spines each near the end, middle femora with 7–8, hind femora with 4–5 much smaller ones. Wing pattern as figured and described by Karsch, the apical hyaline spot being whitish, as stated by Hendel. The stigma is entirely black. Sometimes there is a small subhyaline dot in the dark base of the first posterior cell, near the fourth vein. The veins are yellowish on the hyaline parts, and blackish on the dark parts.

Originally described from Pungo Andongo, and recorded subsequently from S. Nigeria, the species seems to be widely distributed in Central Africa, from East to West. There are some specimens of both sexes from S. Nigeria, Ibadan, 29.xi.1913 (Dr. W. A. Lamborn); from Nyasaland, Mt. Mlanje, 15.iii.13–viii.1913 (S. A. Neave); from Chintechi, Lake Nyasa, ii. 1913 (J. G. Morgan).

The other species, *C. coloniarum*, Speiser, has likewise a wide range, extending from the East to the West Coast.

\* \* \* \* \*

As important additions have to be made to the forms grouped around the old genus "*Ceratitis*," a modification of my table on pp. 217–218 in my previous paper is rendered necessary, beginning with no. 17 (28), as follows:—

17(28). Middle *sep.* well developed; legs short and stout; wings of broader shape; head not balanced.

18(19). Antennae short, with the third joint distinctly pointed at end, and with the second joint prominent and spinulose; arista long plumose; usually three *i. or.* present; genal bristle very strong.

A (B). Basal segment of the costa destitute of bristles before the costal one; basal dark band of the wings perpendicular, beginning at stigma

*Chelyophora*, Rond.

B (A). Basal segment of costa provided with two groups of strong bristles before the costal one; basal band oblique, beginning beyond the stigma

*Bistrispinaria*, Speis.

- 19(18). Third antennal joint rounded at end.
- 20(21). Antennae very short, with the second joint prominent above and densely spinulose; basal dark band of the wings oblique, beginning at fore border beyond the stigma; costal bristle long and strong, as in the preceding genera, like the genal bristle .. *Clinotaenia*, gen. nov.
- 21(20). Antennae less shortened, with the second joint not prominent, never spinulose above; basal band perpendicular, beginning at stigma; costal bristle short and less developed; genal bristle much less developed.
- A (B). Head, in side view, less shortened, the eyes being therefore more rounded; thorax and scutellum prevalently yellowish or reddish, or densely grey-dusted, with black spots (when the thorax is shining black, the scutellum is yellow and not spotted); wings with yellowish bands, which are only exceptionally broadly infuscated, and with blackish basal streaks; the band passing over the hind cross-vein is not, or only exceptionally, united with the basal one.
- 22(23). Arista with short pubescence, which is more distinct on the upper side; frons of the male with conspicuous spatulate appendages  
*Ceratitis*, MacLeay (*s. str.*).
- 23(22). Arista with longer pubescence or even with short plumosity, equally developed on both sides; frons of the male without such appendages.
- a(h)*. Frons flat, normally shaped, with rather thin *s. or.*, which are inserted on less distinct and less converging plates.
- b(c)*. Middle legs of the male broadly feathered, at least on the tibiae; wings with the dark marginal band separated from the basal one beyond the stigma .. .. . *Pterandrus*, Bezzi.
- c(b)*. Middle legs of male simple; marginal band typically united with the basal one.
- d(g)*. Scutellum rounded, swollen, without distinct lateral keels, more or less distinctly trilobate, black-spotted.
- e(f)*. A pair of well developed *oc.* present; first posterior cell not narrowed at end; fourth longitudinal vein ending much beyond the tip of the wing  
*Pardalaspis*, Bezzi.
- f(e)*. *Oc.* quite wanting; first posterior cell distinctly narrowed at end; fourth vein ending at tip of wing .. .. *Capparimyia*, gen. nov.
- g(d)*. Scutellum flat and bluntly triangular, with distinct lateral keels, entirely yellow, not spotted .. .. . *Perilampsis*, gen. nov.
- h(a)*. Frons with very stout *s. or.*, which are inserted on well developed and converging plates, which are besides in the male very prominent and cristate .. .. . *Hoplolopha*, gen. nov.
- B (A). Head distinctly shortened in side view, the eyes being more narrow; thorax and scutellum shining black, sometimes with whitish markings, or even the scutellum white with black spots; wings with blackish bands radiating from the base, which is typically destitute of streaks; arista with long plumosity .. .. . *Trirhithrum*, Bezzi.



**Leucotaeniella**, Bezzi, 1918.**Leucotaeniella guttipennis**, sp. nov. (Pl. xvii, fig. 3).

Very like *trispila* in the scutellar pattern, but distinct from it and from the other species on account of its peculiar wing pattern, which approaches that of the reticulate type.

♀. Length of body 6-6.5 mm. ; of ovipositor 1 mm. ; of wing 5-6.5 mm.

Head exactly as in *trispila*, but without the black ocellar dot, and the semi-circular spot in the middle of the frontal stripe is paler and less distinct. Thorax, scutellum and halteres as in *trispila* ; the black apical scutellar spot is less developed, being much smaller than the space between the apical pair of bristles, and not at all visible from above. Abdomen similar, but the ovipositor not darkened at end ; legs entirely similar. The wings in shape, coloration and venational characters are exactly as in *trispila*, but they show conspicuous differences in the pattern. This last in its general features is of the same type, but the middle and cubital bands are broadly fused together and even with the marginal and anal bands, forming thus a single broad patch filling up the apical two-thirds of the wing, interrupted by some rounded hyaline spots, which form a kind of broad reticulation. The basal band is broadly united with the anal one in the submarginal and first basal cells, thus forming a rounded hyaline spot in the marginal cell just below the stigma, and a hyaline indentation which ends above in the middle of the first basal cell. The stigma is blackish on the basal half, and almost hyaline in the apical one ; the second costal cell is hyaline, with the two ends narrowly infuscated. The anal band is broader, and infuscated on its lower part ; the marginal band has a broad hyaline spot before the end of the marginal cell (which shows therefore two broad hyaline spots), and another at wing border before the end of the submarginal cell, which has another hyaline spot in the middle just below but much smaller than the apical one of the marginal cell ; the first posterior cell is entirely infuscated, yellowish on the basal part and fuscous on the apical, with three rounded hyaline spots, two of which are in the middle (one behind the other), and one at the end in the lower apical corner just above the end of the fourth longitudinal vein and passing a little below it. The second posterior cell has two hyaline spots at the border with a less defined light (but not hyaline) space above them ; the discoidal cell has a rounded hyaline spot before its apex, united with the indentation of the third posterior cell. All these hyaline spots and indentations are broadly margined with fuscous ; but the hind cross-vein is entirely on the yellowish part, being nearer to the fuscous border of the spots of the second posterior cell than to that of the indentation of the discoidal cell.

Type ♀, a single specimen from N. Nigeria, Zungeru, 18.xi.1910 (Dr. J. W. Scott Macfie). An additional female specimen from the same locality and collector differs only in having three (instead of two) hyaline spots in the submarginal cell along the costa, a third (half as small) hyaline spot being present between the two spots of the type.

**Bistrispinaria**, Speiser, 1913.

Owing to the fact that the present very distinct genus was shortly characterised by Dr. Speiser as a section of *Ceratitis*, I will give here a more complete description of it. It is more closely allied to the genera *Chelyophora* and *Acroceratitis*, than to those that have been separated by me from *Ceratitis*, s.l.



Head in front view a little broader than high, and distinctly broader than the thorax; eyes rather narrow; lower occipital swellings much developed; jowls rather broad. Frons broader than the eye, as broad as long, a little concave before the ocelli. Antennae broadly separated from each other at base, inserted near the middle of the eyes, with the second joint very prominent and beset with strong spinules, with the third joint pointed at the end and reaching to the middle of the face; arista long plumose on both sides. Cephalic bristles long and strong, black; the two *s. or.* are placed on converging plates and the second is very stout, curved backwards and inserted over a small black tubercle; three strong *i. or.*; *oc.* very long and strong; *ocp.* black and well developed; genal bristle very long. Frontal stripe with only a few hairs towards the middle. Thoracic chaetotaxy complete; *dc.* placed a little before the line of the *a. sa.*; two *mpl.*; *pt.* long and strong. Scutellum rounded, convex, swollen, less distinctly trilobate, shining black, with four bristles and some stout whitish hairs above. Abdomen ovate, as broad as the thorax, acute at the end, bristly at hind border of the segments; male genitalia small. Legs stout, simple; front femora with a complete row of bristles beneath; middle tibiae with two spurs at end; hind tibiae without distinct posterior row. Wings rather long, with fuscous basal streaks and fuscous bands; basal band oblique, with its upper end beyond the stigma, united with the marginal band; middle band complete; cubital band isolated. Basal segment of costa with two groups of 2-3 erect spines each, the first placed just above the humeral cross-vein, the second just before the costal bristle, which is well developed. First longitudinal vein ending before the small cross-vein; second vein nearly straight; third vein a little curved about the middle of its last section, and then parallel with the fourth or slightly diverging, beset with scattered bristles to beyond the small cross-vein, which is placed near the middle of the discoidal cell; hind cross-vein long and rather sinuous, inwardly oblique, the lower angle of the discoidal cell being acute; discoidal cell about three times as long as the hind cross-vein; anal cross-vein deeply sinuous; the anal cell with a broad point, which is not longer than the second basal cell.

1. ***Bistrispinaria fortis***, Speiser, 1913. (Pl. xvii, fig. 5).

A stout species, distinguished by its frons, antennae and legs.

♂ Length of body 5 mm.; of wing 6 mm.

Head entirely pale yellowish, opaque, with a dark brown subocular spot; face whitish, with a dark yellowish stripe at the mouth-border; frons with a darkish rounded middle spot. Antennae entirely yellowish, with the third joint distinctly darker; the spinules of the second joint are black and thick. Palpi whitish, with black bristles; proboscis yellowish. All the bristles are black, like the hairs on middle of the frons. The lower occipital swellings are whitish and clothed with white hairs. The thorax is blackish on the dorsum but densely grey-dusted and clothed with pale yellowish hairs; on the disc there are three narrow longitudinal darker stripes, the lateral ones being broadly interrupted at the suture; on the sides there are two broad, subquadrate, shining black, ill-defined spots; the humeri are yellowish; on the postalar calli there is a rounded, deep black, opaque spot. The pleurae are reddish brown, rather shining, with a whitish yellow patch on the upper border of the mesopleura, continued below the root of wings, and

there united with the double whitish hypopleural spot; the hairs of the pleurae are white on the whitish parts, and black on the dark parts. Postscutellum shining black; mesophragma reddish brown, but densely grey-dusted. Scutellum shining black, with a narrow middle longitudinal yellow stripe, and with a yellow stripe on each side; the bristles are black and the hairs pale yellowish. Halteres pale yellowish. Abdomen with black bristles and yellowish hairs; it is blackish, but grey-dusted, with a narrow whitish hind border to the segments. Legs pale yellowish, with the femora broadly infuscated and the four posterior tibiae darker on the basal half; bristles black. Wings whitish hyaline, with blackish basal streaks and with fuscous bands; veins black, but the costa and the first longitudinal vein whitish at the stigma. At the base there is a short blackish band, beginning at the humeral cross-vein; there is a blackish streak in each cell, broader and more sharply defined near the fore border; but the anal cell has no middle streak. Stigma whitish, with the base narrowly darkened. The first band is oblique, beginning at fore border just beyond the stigma, passing over the small cross-vein, and ending evenly and symmetrically at the end of the sixth vein. The costal band is united with the above-named band, extending below to the third vein and on the apical part passing even a little beyond it; it includes 6-7 darker dots along the fore border, being moreover narrowly hyaline near the costa. About at middle of the last section of the third longitudinal vein there arises from the costal band the middle band, which is narrow and oblique, irregularly interrupted at base, and crosses just beyond the middle the last section of the fourth vein, ending at the border a little after the end of the fourth vein. The cubital band is broader than the middle one, extends from the hind border across the hind cross-vein, and ends roundly above it in the first posterior cell, being distinctly separated from the basal band. Axillary lobe hyaline, only with a diffused greyish shade at the apex.

Originally described in the male sex from Kamerun, Soppo, xii. 1912; there is a male from Uganda, Kampala, 10.xi.1915 (*C. C. Gowdey*).

#### ***Clinotaenia*, gen. nov.**

Notwithstanding the obtuse third antennal joint, the present new genus seems to be more closely allied to the preceding one than to the following genera. Its wing pattern is very like that of *Bistrispinaria*, and is not very different from that of *Trypeta grata*, Wied., a species which might therefore be better placed here than in *Leucotaeniella*. Loew (Berl. Ent. Zeits., v, 1861, p. 268) has pointed out that the allies of *T. grata* are to be found only in the neotropical fauna; the American forms with a similar wing pattern are those of the genus *Anastrepha*, which are however very different in their structural characters; but it is interesting to note that the end of the fourth longitudinal vein in the species here described shows a slight tendency to be curved upwards. The new genus *Clinotaenia* is closely allied to the Oriental genus *Gastrozona*, but has only two *i. or.*, and different body and wing patterns. It must be recorded that Prof. De Meijere has recently described\* from Java a species of *Anastrepha* (*A. extranea*), which however cannot be placed in the American genus, nor in the present one.

\* Tijdschr. v. Entom., lvii, 1914, p. 193, pl. v, fig. F.

Head in front view distinctly higher than broad, as broad as the thorax; frons quite flat, proportionally narrow, as broad as the eye, longer than broad; occipital lower swellings distinct, but less developed than in *Bistrispinaria*; eyes narrow, the head being very narrowed in profile; jowls rather broad. Antennae approximate at base, inserted distinctly above the middle of the eyes; they are very short, with the second joint rather prominent above and beset with short and thick spinules; third joint rounded at tip, not reaching the middle of face; arista long plumose. Cephalic bristles well developed and black; the *s. or.* are inserted over less distinct and not converging plates, and the anterior one is not specially dilated; only two *i. or.*; *oc.* well developed, but rather short; *ocp.* black and acute; genal bristle of medium size. Thoracic chaetotaxy complete, with black and strong bristles; middle *scp.* long and approximated; *dc.* on a line with the *a. sa.* or only a little beyond it; two *mpl.*; *pt.* as strong as the *st.* Scutellum swollen, rounded, not trilobate, with four bristles, the apical ones decussate, and with sparse thin hairs; it is whitish yellow, with three black spots. Abdomen oval, as broad as the thorax, bristly on sides and at end, with whitish transverse bands; ovipositor as long as the last three abdominal segments together, triangular, rather swollen at base, broadly obtuse at end. Legs short and stout; front femora with a complete row of strong bristles beneath; middle tibiae with a single spur at end; hind tibiae with a row of strong bristles in the middle of the outer side. Wings proportionally long, with blackish basal streaks and with fuscous bands, the first of which is placed obliquely (whence the generic name); costal bristle strong and long, but there are no other strong bristles before it. First longitudinal vein ending before the small cross-vein; second vein about straight; third vein beset with dense bristles throughout its whole length, its last portion parallel with the last portion of the fourth; fourth vein slightly but distinctly curved upwards at end; small cross-veins long and oblique, placed beyond the middle of the discoidal cell; hind cross-vein straight, inwardly oblique, the lower angle of the discoidal cell being acute; discoidal cell three times as long as the hind cross-vein; anal cross-vein deeply angulate in the middle; lower point of the anal cell of medium length, as long as the second basal cell.

Type: the following new species.

***Glinotaenia anastrephina*, sp. nov. (Pl. xvii, fig. 6).**

A pretty species readily distinguished by its antennae and wing pattern.

Length of body 5.5 mm.; of ovipositor 1 mm. (when completely exerted 2.2 mm.); of wing 5.5 mm.

Head entirely pale yellowish, with a broad blackish patch on the occiput from the neck to the upper corner of the eyes, with a small brownish subocular spot on the jowls; towards the middle of the frons there is a reddish yellow spot. The frons is opaque, only the narrow plates bearing the *s. or.* being shining; ocellar dot blackish. Antennae reddish yellow, the second joint appearing infuscated owing to the numerous black spinules. Proboscis and palpi yellowish, the latter with rather thick black bristles. Occipital swellings whitish and clothed with whitish hairs, with a few short and thicker black ones at lower border. Frontal stripe in the middle with a few short black hairs. The thorax is blackish on the



dorsum, but densely dark grey tomentose and with short golden-yellow pubescence; the sides above the notopleural line and above the root of the wings are shining blackish brown, while on the postalar calli there is a rounded, velvety black spot; on each side, behind the suture and above the blackish supra-alar patches, there is a narrow and ill-defined, yellowish stripe. Pleurae blackish, partly reddish brown, shining, with a broad oblique whitish patch across the meso- and pteropleura, uniting in front with the whitish immaculate humeral callosities; there is also a broad double whitish hypopleural spot; sternopleura shining black; mesopleura hairs whitish. Postscutellum and mesophragma shining black. Scutellum shining whitish, with whitish hairs; there is a narrow black stripe at base, and three broad black spots, which are hardly visible from above, the apical one occupying the whole space between the two apical bristles, and the lateral ones having the lateral bristles inserted at their outer borders. Squamulae and halteres whitish. Abdomen blackish, but clothed with dense grey and white dust; first segment shining black on the basal half, white-dusted on the apical half, thus forming a complete and broad cross band; second segment entirely brownish grey; third and fourth entirely white, with a narrow blackish basal band. The abdominal hairs are white on the white, black on the dark parts; all the bristles are black. Venter reddish brown. Ovipositor entirely reddish, darker at base, with short black or dark brownish hairs. Legs with dark reddish coxae and with blackish femora, which are dark reddish at base; tibiae and tarsi pale yellowish, but the latter darkened at end; bristles black; hairs dark on femora and whitish on tibiae. Wings whitish hyaline, with black veins, but the costa and the first longitudinal are whitish on the hyaline parts, like the fourth and fifth veins. At the extreme base there is a short fuscous band, extending from the humeral cross-vein to the base of the second basal cell; after this band there are the blackish streaks, which are broad and placed one in each cell, except the anal cell, and are present even in the base of the submarginal cell and in the upper corner of the base of the discoidal cell. The second costal cell is infuscated at the two ends; the stigma is hyaline, with a blackish base. The bands are deep fuscous, the darker spots of the marginal band along the costa being thus less distinct. Basal band oblique, beginning at fore border beyond the stigma, passing across the small cross-vein and ending narrowly at the tip of the sixth vein; it is almost straight on its outer border, with fuscous teeth on the inner edge, two of which extend into the third posterior cell; at base of the discoidal cell it is united with the fuscous basal streak of the same cell. The marginal band extends below to the third vein, passing even below it near the apex and ending at wing border near the middle of the first posterior cell. The oblique middle band is rather broad; it begins at middle of the last portion of the third vein and ends at wing border just below the end of the fourth vein; the hyaline indentation between the marginal and the middle band is narrower than the terminal part of the marginal band itself. Cubital band less oblique, beginning at hind wing border, passing across the hind cross-vein and ending rather narrowly above it in the first posterior cell, quite separated from the basal band; its external border is convex, while the internal one is concave, the band being thus distinctly arcuate. Axillary lobe entirely hyaline, like the alula.

Type ♀, a single specimen from Nyasaland, Mt. Mlanje, 3.xii.1913 (*S. A. Neave*).  
(637)



**Pterandrus, Bezzi, 1918.****Pterandrus rosa, Karsch, var. fasciventris, nov.**

Differs from the type in having well developed blackish bands on the abdomen.

♂♀. Length of body 5-5.5 mm.; of ovipositor about 1 mm.; of wing 5.5-6 mm.

Head, its appendages and bristles exactly as in *rosa*. Thorax and scutellum likewise, but the dorsum of the mesonotum in fully coloured specimens seems to be darker and more densely grey-dusted. The chaetotaxy is the same, the single *mpl.* being present. The abdomen in both sexes shows a distinct, complete, blackish, rather shining cross band on the apical half of the second segment; the third and fourth segments are whitish, but in the female they have a distinct dark cross band at base. The ovipositor is shining reddish, with a distinct black base and with a less intense apical black border, but these dark parts are not sharply separated. The legs are as in *rosa*, the male having the middle femora quite simple, and the middle tibiae feathered on the apical half alone; the front femora of the male are not densely ciliated. The wing pattern is the same as in *rosa*, but the stigma is blackish, with the apical third hyaline.

Type ♂, type ♀, and an additional female specimen from Uganda, Entebbe, 17.viii.1911 (*C. C. Gowdey*); another male specimen (more lightly coloured owing to immaturity) from Uganda, Kampala, 5.xii.1916 (*C. C. Gowdey*).

The species *Pterandrus anonae*, *P. colae*, *P. rosa* and *Pardalaspis morstatti* are very closely allied and have a similar wing pattern; the feathering of the middle legs in the male decreases from the two former (which have femora and tibiae feathered) to the third, in which only the tibiae are feathered, and to the fourth, in which they are not feathered at all. The two former species agree also in the ciliation of the front femora, which is lacking in the two latter; *morstatti* in the length of the ovipositor agrees with *colae*, while *anonae* and *rosa* have a short ovipositor. In a more natural classification *P. morstatti* must be placed in the genus *Pterandrus*, notwithstanding the lack of feathering on the middle legs in the male.

**Pardalaspis, Bezzi, 1918.**

I will give here another table for determining the rather numerous species of the present genus, excluding *inscripta*, Graham (belonging to *Trirhithrum*), and with the addition of two new species.

- 1(18). Wings with the band across the hind cross-vein quite isolated, and without a complete middle band, or rarely with a small isolated streak on the last portion of the fourth longitudinal vein.
- 2(15). The black spots of the scutellum very broad, quadrate or rectangular in shape, closely approximated, and nearly covering the whole surface.
- 3 (4). Wings with the marginal band isolated (as in *Pterandrus*); arista shortly plumose . . . . . *morstatti*, Bezzi.
- 4 (3). Wings usually with the marginal band broadly united at stigma with the basal one; when they are separated, the arista is pubescent only.
- 5(14). Last portion of the fourth longitudinal vein destitute of an oblique dark streak across its middle.

- 6 (7). Two strong *mpl.* present; wings broad, with strikingly developed basal streaks and dots, and with the bands much infuscated; head of the male with a peculiar, striking coloration . . . . . *punctata*, Wied.
- 7 (6). Only one *mpl.* present as a rule; wings with a less developed basal pattern and with pale yellowish bands, which at most are infuscated only towards the hind border; head of the male not peculiarly coloured.
- 8 (9). Thorax destitute of black spots; species of greater size (8 mm.)  
*brêmei*, Guér.
- 9 (8). Thorax with distinct black spots, at least on the sides beyond the suture; size smaller (not over 7 mm.).
- 10(11). Occiput above with broad, shining black spots; the shining black parts on back of mesonotum more developed than the yellow ones; scutellum black, with a narrow yellow base . . . . . *melanaspis*, sp. nov.
- 11(10). Occiput yellow above or only a little infuscated; yellow parts of back more developed than the black ones; scutellum yellow with black spots.
- 12(13). Humeri with a distinct black spot; sides of thorax with black spots before the suture; scutellum with two basal black spots besides the three apical ones . . . . . *cosyra*, Walk. (*giffardi*, Bezzi).
- 13(12). Humeri and sides of thorax before the suture destitute of black spots; scutellum with no distinct basal spots.. . . . *silvestrii*, Bezzi.
- 14 (5). Last portion of the fourth vein crossed over the middle by a well developed, oblique, dark streak; wings short and broad . . . . . *antistictica*, Bezzi.
- 15 (2). The black spots of the scutellum much smaller and broadly separated, the outer ones being more rounded; the scutellum therefore mainly yellow.
- 16(17). Scutellum with three black spots; wings with the marginal and basal bands wholly separated beyond the stigma . . . . . *flexuosa*, Walk.
- 17(16). Scutellum with five spots; the two above-named bands united and fused with the stigma . . . . . *quinaria*, Bezzi.
- 18 (1). The band over the hind cross-vein not isolated; or when its union with the other band is less distinct, there is a complete middle band.
- 19(20). The marginal band united with the basal one and with the stigma; the band over the hind cross-vein united with the basal one; no complete middle band . . . . . *stictica*, Bezzi.
- 20(19). The marginal band separated from the basal one beyond the stigma; the band on the hind cross-vein united with the marginal one; a complete middle band across the last section of the fourth vein.. . . . *aliena*, sp. nov.

#### ***Pardalaspis melanaspis*, sp. nov.**

Allied to *P. cosyra* (*giffardi*), but smaller and at once distinguished by the broad black occipital patches, and by the more extended shining black pattern of the thorax and scutellum.

♂♀. Length of body 3·2–3·5 mm.; of ovipositor 0·5 mm. (when completely exerted 1·5 mm.); of wing 3·2–3·5 mm.

Head pale yellowish, with reddish-yellow frontal stripe, with a black, rather broad, rounded ocellar spot, and a broad, shining black patch on upper part of the occiput, extending from the neck to the eyes, but leaving a narrow yellow border near the

eyes. There is no subocular spot on the jowls. The antennae are entirely yellow, about as long as the face; second joint not prominent, never spinulose; third joint broad and long, attenuated but rounded at end; arista dark, shortly pubescent on both sides. Upper mouth-border rather prominent and shining. Palpi broad, flat, yellow, with short black bristles; proboscis yellowish. Cephalic bristles black, but the *prt.* and the very thin and indistinct genal bristles are yellowish, the former sometimes infuscated; the hairs of the jowls and of the lower part of the occiput are yellowish; frontal stripe with sparse indistinct darkish hairs. Thorax entirely pale yellowish and rather shining, with broad black spots on the dorsum; it is clothed with short, pale yellowish hairs. Humeri with a broad rounded black spot; from the humeri to the transverse suture extends a broad rectangular blackish-brown shining patch, reaching inwardly to the dorsocentral lines, and including a deep black, opaque spot above the notopleural line with the anterior *npl.* Between these two black patches there is a rather broad, shining black, middle stripe, extending from the black scapular region to the suture, and ending there truncately. Beyond the suture the back is entirely shining black, with a concave front edge; along the middle line there is a pale yellow, longitudinal stripe, which is a little narrower than the presutural black stripe and ends with a transverse, pale yellowish streak in front of the scutellum, thus forming a **1** shaped mark. Above and in front of the root of the wings, and on the postalar calli there are rounded, deep black, opaque spots. The pleurae are of a shining pale yellowish colour, whitish on the upper part of mesopleura, and there with a narrow longitudinal black stripe, extending from below the humeri to the *mpl.* bristle. The upper border of the sternopleura is pale; there is a broad double whitish hypopleural spot. All the bristles are black and strong, but the well developed middle *scp.*, and the thin *pt.* and *st.*, are pale yellowish; one *mpl.* only; *dc.* placed before the line of the *a. sa.* Scutellum rounded, convex, slightly trilobate; it is entirely shining black, with a narrow, pale yellowish, basal border; it has rather long and numerous whitish hairs on the disc, and four long black bristles, the apical ones not decussate, or only slightly so at the tips. Postscutellum shining black; mesophragma yellow, clothed with dense whitish dust on the upper half. Squamulae whitish; halteres yellowish. Abdomen entirely yellow, rather shining, with numerous blackish hairs, and with black bristles at end and on sides. The narrow hind border of the first segment in both sexes and almost the whole of the third segment in the female, are densely clothed with whitish dust, forming thus two white cross bands. Ovipositor shining yellow, with yellowish hairs, with the basal segment bluntly triangular, about as broad as long, swollen. Legs entirely pale yellowish, with yellowish pubescence; the long bristles of the underside of the front femora, and those of the hind tibiae are likewise yellowish; the single spur of middle tibiae is black. Wings proportionally long, with short and less developed costal bristle; the veins are entirely pale yellowish, and typically disposed; the stigma is about twice as long as broad, quite yellow, or rarely with the apical half subhyaline. The pattern is yellowish and shaped as in *cosyra*, but the basal dark streaks are less numerous, the second basal cell having a single blackish dot, and the anal cell having no dots at all.

Type ♂, type ♀, and an additional female specimen from Cape Colony, Grahams-town, 9.ii.1905 (*C. W. Mally*).



***Pardalaspis aliena*, sp. nov.**

Allied to *cosyra* and *silvestrii*, but distinct from them as well from all the other species in having the costal band of the wings separated from the basal one, and in having a complete middle band across the last section of the fourth longitudinal vein.

♀. Length of body 4.2 mm. ; of ovipositor 0.6 mm. ; of wing 4.2 mm.

Head pale yellowish, without any dark spot, only with a small black ocellar dot. Face whitish, not prominent at the mouth-border. Antennae wanting in the type, only the shortened and pale yellowish basal joints being present. Palpi whitish, not very broad, without bristles, with whitish hairs ; proboscis pale yellow. Cephalic bristles black ; *oc.* well developed. Thorax shining yellow, with short whitish pubescence. Humeri whitish, immaculate ; above them there is on each side a shining black, longitudinal stripe, which ends before the suture, but is continued behind it along the dorsocentral lines by a black subquadrate spot on the *dc.* bristles, and by a broad stripe in front of the scutellum, including a broad whitish patch, in the shape of a rounded spot. Above the notopleural line and above the root of the wings there are the usual velvety black, opaque spots, which are separated by the whitish notopleural callus ; on the postalar calli there is also a rounded, deep black spot ; above the shining supra-alar patch there is on each side a short whitish stripe. The pleurae are pale yellowish and shining, with a white mesopleural spot and a double white hypopleural spot. Postscutellum deep black ; mesophragma pale yellowish, with faint whitish dust. Scutellum shining whitish, with three subquadrate, equally broad spots at hind border ; it is convex and less distinctly trilobate. All the thoracic bristles are black, even the middle *scp.* and the *pt.*, only the *st.* being yellowish ; one *mpl.* Squamulae white ; halteres whitish. Abdomen shining yellow, with whitish pubescence and with black bristles at sides and at end ; the narrow hind border of the first and third segments is covered with whitish dust, forming thus a very narrow and ill-defined white cross band ; ovipositor shining yellow ; venter pale yellowish. Legs entirely pale yellowish and with concolorous bristles and hairs, only the spur of middle tibiae being black. Wings with entirely pale yellowish veins, and with a very short and black costal bristle ; the bands are pale yellow, infuscated towards the hind border ; the stigma is yellow, with the extreme upper corner subhyaline. At base there are some darkish dots and streaks, three in the second costal cell, one streak in the other cells and none in the anal cell. The basal band is perpendicular, beginning at stigma, including the small cross-vein, which is situated just at its outer border, and ending with a slight curve at apex of the sixth longitudinal vein. After this band there is a complete hyaline band, which extends to the fore border just beyond the stigma ; the marginal band is therefore separated from the basal one. The marginal band extends below to the third vein, passing beyond it with its infuscated end, and ending at apex about in the middle of the first posterior cell ; it includes two darker marginal dots in the marginal cell, and a rounded hyaline spot at end of the second vein. A little before the middle of the marginal band arises the narrow and complete middle band, which, passing across and beyond the middle of the last section of the fourth longitudinal vein, ends infuscated at hind border in the upper third of the second posterior cell. The cubital band extends across the hind cross-vein and is only slightly oblique ; above it becomes gradually paler, but is distinctly united with the costal band just



near its base. The small cross-vein is placed noticeably before the middle of the discoidal cell; the last portions of the third and fourth longitudinal veins are slightly divergent; the hind cross-vein is straight and placed a little obliquely; the produced lower angle of the anal cell is rather broad, and a little shorter than the second basal cell.

Type ♀, a single damaged specimen from Cape Colony, Grahamstown, 30. xi. 1908 (C. W. Mally).

### **Capparimya**, gen. nov.

I will erect here this new genus (which, so far as at present known, is not Ethiopian but only Mediterranean) with *Ceratitis savastani*, Martelli,\* as type. This species shows all the characters of *Pardalaspis*, as well as the same coloration of body and the same wing pattern, but it is at once distinguished by the complete want of the *oc.* bristles, a character which is present in none of the allied forms. The ending of the fourth longitudinal vein at the tip of the wing is also unique among the allies of *Ceratitis*, and it is rendered even more evident by the distinct narrowing of the first posterior cell, due to the curving downwards of the third longitudinal vein in its last portion.

The erection of a new genus for the present species is supported by the fact that it is a gall-making insect; the young buds of the flowers of *Capparis spinosa*, L. (whence the generic name), in which the larvae live, become hypertrophied, deformed and arrested in their development, the effects being similar to those caused by the Itonid midge, *Asphondylia capparis*, Rübsaamen. The gall of *Capparimya savastani* is included in the great work of Prof. Houard†; and it must be remembered that all the larvae of the allied forms live in fruits and are not galligenous, and that the faculty of making galls is very rare in the subfamily CERATITINAE, while it is not rare in the subfamily TRYPANEINAE.

The main characters of the new genus are as follows:—*Pvt.* yellow; *ocp.* black and acute; two *i. or.*; the *s. or.* are inserted on indistinct and not converging plates; genal bristle thin and yellow; *dc.* placed only a little behind the line of the *a. sa.*; one *mpl.*; *pt.* as developed as the *st.*, and both yellowish in colour, like the middle *scp.*, while all the other bristles are black. Wings with a short but strong costal bristle; first longitudinal vein ending noticeably beyond the small cross-vein, which is placed before the middle of the discoidal cell; third vein bristly to the middle of its last portion; first posterior cell narrower at end than in the middle, the last portion of the third vein being curved downwards before the end; fourth vein ending very near the tip of the wing; lower angle of the discoidal cell acute, the hind cross-vein being however only a little oblique; lower point of the anal cell acute and produced, but a little shorter than the second basal cell.

The single species at present known has been found only in Sicily and in Southern Italy.

\* Boll. Arboric. Ital., vii, 1911, p. 19, figs. 1-4, and Mem. R. Accad. Zelanti, (3) vii, 1912, p. 50, figs. 1-4. In the Zoological Record, vol. L, p. 423, the species appears as published in 1913.

† Les Zoocécid. des plantes d'Europe, etc., iii, 1913, p. 1355, n. 6730.

**Perilampus**, gen. nov.

This new genus is erected here with *Carpophthoromyia pulchella*, Austen, as type, and includes *Carpophthoromyia formosula*, Austen, but not *Trypeta grata*, Wied., which probably belongs to *Clinotaenia*, as stated above. It comprises very beautiful (whence the generic name) Ethiopian flies, which agree in coloration of the body and in wing pattern, as well in the following characters:—

Head in front view broader than high, the face being a little shorter than the frons and the jowls very narrow; eyes rounded; occipital lower swellings less developed; frons about as broad as long, flat, with the shining vertical plates short, not prominent, slightly converging in front; face distinctly concave in the middle and prominent at mouth-border. Antennae inserted at middle of eyes, rather long but always shorter than the face; second joint not prominent, never spinulose above; third joint twice as long as the second and obtuse at end; arista with long pubescence, or even shortly plumose, the feathering being much narrower than the breadth of the third joint. Palpi broad and shortly bristled; proboscis short. Cephalic bristles black; *ocp.* numerous and long, black, acute; *oc.* strong and long; two *i. or.*; genal bristle black and rather long. Thorax shining black on the back of mesonotum and adorned with characteristic transverse bands of minute, pale-coloured hairs; pleurae with whitish mesopleural stripe and with double hypopleural spot; scutellum quite yellow, destitute of black spots. Thoracic chaetotaxy complete; middle *scp.* long and approximated; *dc.* placed a little beyond the line of the *a. sa.*; one *mpl.*; *pt.* as strong as the *st.*; all the bristles are black. Scutellum broadly triangular, not trilobate, rather flat above, with distinct lateral keels, pubescent above and with four bristles. Abdomen shortly oval, distinctly broader than the thorax at base, and with black bristles at end and on sides. Legs stout, with complete rows of bristles on front femora and on hind tibiae; middle tibiae with a single spur. Wings broad and long, with a blackish and characteristic pattern, the middle band of which is more or less complete, and the basal band perpendicular and beginning at the stigma. Costal bristle short but strong; first longitudinal vein ending opposite to the small cross-vein; second vein straight; third vein bristly to the middle of its last section; third and fourth veins slightly divergent towards the end, and thus the first posterior cell not narrowed outwardly; fourth vein ending much behind the tip of wing; small cross-vein before the middle of the discoidal cell; hind cross-vein oblique inwardly; point of the anal cell a little shorter than or as long as the second basal cell.

**Perilampus pulchella**, Austen, 1910.

Of the present species, known from Uganda and Kamerun, there is a specimen from S. Abyssinia (*R. J. Stordy*). The species seems therefore to have a very wide distribution over the whole centre of the Ethiopian Region.

**Hoplolopha**, gen. nov.

This new genus is a very interesting one, because, although it is without doubt closely allied to *Ceratitis* (*s. l.*) and has a wing pattern very like that of the preceding genus, it shows in the male sex on the frons the cristiform protuberances with

incrassated bristles (whence the generic name), which are characteristic of other Trypaneid genera, like *Straussia*, *Vidalia*, *Stemonocera*, etc.

Head in front view a little higher than broad. Eyes rather narrow; lower occipital swellings well developed; jowls as broad as the breadth of the third antennal joint. Frons longer than broad, narrower than the eye; in the female it is flat, while in the male it is distinctly concave in the middle; the shining orbital plates are produced beyond the middle of the frons, and converge in front, and moreover in the male they are prominent and cristiform. Face shorter than the frons, rather flat, and with a less prominent mouth-border. Antennae inserted at the middle of the eyes, proportionally long, but always shorter than the face; second joint not specially prominent, nor spinulose; third joint elongate linear, rather narrow, about three times as long as the second, rounded at tip; arista pubescent, the breadth of its feathering being much narrower than the breadth of the third antennal joint. Palpi broad; proboscis short. Cephalic bristles black and strong; *ocp.* thin and pointed; *oc.* strong and long; the three *s. or.* are in both sexes very long and incrassated, chiefly the two former, curved backwards, but in the male they are distinctly longer: two *i. or.*, rather short and much shorter than the superior ones; genal bristle rather short. Thorax yellowish grey, pale pubescent, with ill-defined black pattern, and with less striking, whitish, pleural markings; scutellum swollen, rounded, yellowish, with three broad, shining black spots. Middle *sep.* long, approximated, black like all the other bristles; *dc.* a little beyond the line of the *a. sa.*; one *mpl.*: *pt.* as strong as the *st.*; four *set.*, the *a. set.* diverging. Abdomen short and oval, with bristles on sides and at end; male genitalia developed; ovipositor narrow and cylindro-conical, swollen, as long as the last three abdominal segments together. Legs short and stout; front femora with a complete row of bristles below; middle tibiae with one spur; middle and hind tibiae with an external row. Wings long but proportionally not broad, with a short but strong costal bristle, with basal dark streaks and dots, and yellowish bands; basal band beginning at stigma and perpendicular; middle band complete. First longitudinal vein produced beyond the small cross-vein; second vein straight; third vein densely setigerous to the middle of its last portion; small cross-vein oblique and placed considerably before the middle of the discoidal cell; third and fourth slightly divergent at end, the fourth ending much after the tip of wing and the first posterior cell not narrowed outwardly; hind cross-vein before the middle of the first posterior cell, very oblique inwardly, the lower angle of the discoidal cell therefore acute; discoidal cell three times as long as the hind cross-vein; anal cross-vein deeply sinuous, the lower angle of the anal cell very long longer than the second basal cell; axillary lobe broad and semicircular, in the male separated by a deeper incision of the hind border at the end of the sixth longitudinal vein.

Type: the following new species.

**Hoplolopha cristata**, sp. nov. (Pl. xvii, fig. 7).

A robust fly of comparatively large size, at once distinguished from all the allied forms with a typical *Ceratitis*-like wing pattern on account of the cristate frons of the male.



♂♀. Length of body 6·5-7 mm.; of ovipositor 1 mm.; of wing 7·5-8 mm.; breadth of wing about 3 mm.

Head yellowish, but more whitish on the face, on the linear cheeks and on the lower occipital swellings; the frons is opaque and immaculate, but the ocellar and vertical regions and orbital plates are shining and of a more reddish colour; below the lower corner of the eyes there is an ill-defined brownish genal spot, more developed in the female than in the male. Antennae entirely yellowish, the third joint infuscated along the upper border; palpi pale yellowish, with some black bristles at the end; proboscis reddish. All the cephalic bristles are black, even the *pv.* and the genal ones; the lower occipital hairs are white, but along the lateral borders of the oral cavity there is a rather dense row of short bristly black hairs. Thorax on the dorsum reddish brown, but covered with a dense grey dust and with pale pubescence: it is opaque, with a more or less distinct trace of a middle longitudinal blackish stripe; on the dorsocentral lines there is on each side a blackish stripe, which is interrupted to form a rounded postsutural spot, and a broader and shining elongate spot in front of the scutellum; above the wings there is also on each side a blackish stripe, and two broad blackish spots, the anterior shining, the posterior deep black. Humeral calli reddish or pale yellowish, not spotted. Pleurae reddish yellow, rather shining, with white dust and with whitish mesopleural stripe, more distinct in the male, and with rather long, pale yellowish hairs, which are however dark on the lower part of the mesopleura, while on the breast they are white. The double whitish hypopleural spot is more distinct in the male. Postscutellum shining black, more or less reddish below and on sides: mesophragma reddish with grey dust. Scutellum with three very extended, shining black, rectangular spots, and between them very narrow, yellowish or reddish stripes; in the narrowly yellow base there are two dark spots, in contact with the hind border of mesonotum. Halteres whitish, with reddish knob; squamulae whitish, with narrow dark border. All the bristles are black, even the middle *sep.* Abdomen reddish yellow, with grey dust; the second, third and fourth segments are blackish at base, more broadly in the second, which is almost entirely black, while the third is more densely clothed with whitish dust, thus forming a transverse band, more distinct in the female. The hairs are whitish on the pale, and blackish on the dark parts; the bristles are black. Male genitalia black and black-haired; ovipositor shining reddish, darkened at tip, with darkish hairs. Legs entirely pale yellowish, with blackish pubescence, black bristles and black claws. Wings hyaline, iridescent, with yellowish veins, only those of the lower part of the base being blackened. The extreme base, before the humeral cross-vein, is infuscated as a short yellowish band. The basal blackish dots and streaks are numerous, and are more developed in the female than in the male; they invade the anal cell also, and even the base of the discoidal and third posterior cells. The stigma is yellowish, darker on the basal half. The bands are yellowish, infuscated towards the apex and the hind border of wing. Basal band perpendicular, going from the base of the stigma to the end of the sixth longitudinal vein, but not extending into the axillary cell, or only slightly so; the small cross-vein is placed just at the anterior border of this band. The costal band is broadly connected with the basal one, its lower border going exactly along the third vein, surpassing it only near the tip of the wing, and there ending (infuscated)



before the middle of the first posterior cell; it contains two rather large fuscous spots on the fore border in the marginal cell. From the costal band, about at middle of the last portion of the third vein or a little beyond it, departs the fuscous narrow middle band, which, crossing obliquely beyond the middle of the last portion of the fourth vein, ends at the hind border just below the tip of the fourth vein itself. The fuscous cubital band is about twice as broad as the middle one; it begins at the hind border of the wing symmetrically with the end of the fifth vein, and passing over the hind cross-vein fills up broadly the end of the discoidal cell, and ends, more pale-coloured, in the first posterior cell, but without reaching either the basal or costal band; the base of the first posterior cell is thus completely hyaline. The broad axillary lobe is hyaline, with an ill-defined fuscous middle spot; the alula is quite hyaline. The oblique folds in the discoidal and third posterior cells are about as dark as the axillary vein.

Type ♂ and type ♀, a single couple of specimens from British East Africa, Kabete, 28.viii.1914 (*T. J. Anderson*).

### **Trirhithrum**, Bezzi, 1918.

The peculiar character of the wing pattern in the present genus is not (as wrongly indicated on p. 233 of my previous paper) that the middle band is united to the marginal one, but that the cubital band (or the band on the hind cross-vein) is united to the basal or anal band. Another error is to be found in p. 239 in the description of the new species *Tr. occipitale*, which has the thorax shining black, and not shining yellowish.

To the present genus is to be ascribed also *Ceratitis inscripta*, Graham, which is the same as *T. coffeae*, Bezzi, as stated by Dr. G. A. K. Marshall; and the following very distinct and robust new species, which seems to be allied to *T. nitidum*, v. Roeder, in having a complete middle band on the wings.

### **Trirhithrum validum** sp. nov.

A robust fly of comparatively large size, entirely shining black, with whitish mesopleural stripe and whitish scutellum, and with a complete middle band on the wings, which have also rather distinct black streaks at the base.

♀. Length of body 7.5 mm.; of ovipositor 1.5 mm.; of wing 8 mm.

Head with the occiput shining reddish in the middle and above, black on the sides; frons dull yellowish, face whitish on its lower part, jowls reddish like the lower occipital swellings, which are shining black above. The frons is about as broad as long, unspotted, only the ocellar and the narrow and short orbital plates being shining reddish. The cheeks are whitish, but their upper half, by the roots of the antennae, is purplish. Antennae wanting in the case of the type. Upper half of the face, just below the antennal root, blackish and grey-dusted. Jowls of a purple colour, with a dark brown spot below the eye. Palpi and proboscis reddish brown. All the cephalic bristles are black, even the *prt.* and the genal ones; two *i. or.*; *oc.* very strong and long; occipital hairs black, even below; mouth-border on the sides with a row of black bristly hairs. Thorax shining black on the back, with short dense black pubescence; humeri black, narrowly reddish brown behind;

pleurae shining brown, with a broad oblique whitish mesopleural stripe, on which there are long and pale yellowish hairs, while the hairs are black on the rest; no distinct lighter hypopleural spots. Postscutellum and mesophragma shining black. Scutellum of a semicircular shape, flattened above, shining whitish, with three broad shining black spots at hind border which are not visible from above; it is clothed above with rather long whitish hairs and bears four bristles, the middle pair being not decussate. Thoracic bristles black, even the long and approximated middle *sc.*; *dc.* placed on the line of the *a. sa.*; one *mpl.*; *pt.* stronger than the *st.* Halteres blackish, with yellowish base; squamulae dark yellowish, with blackish border and with dark fringe. Abdomen with parallel sides, not broader than the thorax and not narrowed at base; it is shining black, clothed with black hairs, and with black bristles on sides and at end; the hind border of the first, and the whole of the third segment are densely clothed with a whitish-grey dust, thus forming two transverse bands, which are clothed with whitish hairs; the fourth segment is reddish brown on the middle; ovipositor elongate triangular, as long as the last three abdominal segments together, depressed, shining black, with black hairs and with the apical segment reddish; venter shining black. Legs with reddish brown coxae and femora, the latter more blackened outwardly, and with black pubescence; tibiae and tarsi pale yellowish and with whitish pubescence; bristles of the femora black, those of the tibiae tawny. Wings long and narrow, hyaline, with a blackish pattern; costal bristle strong but short; veins dark brown or blackish, but the costa and the first longitudinal pale yellowish on the basal hyaline indentation. The extreme base is blackened, being separated from the basal band by a triangular hyaline indentation, the base of which is at costa in the two basal cells, and the vertex is below the end of the second basal cell; in this hyaline part there are some blackish dots, likewise in the basal blackish part there are some narrow hyaline streaks, forming thus a *Ceratitis*-like pattern, though closer and less distinct. The stigma is entirely black. The basal band begins at the stigma and extends to the hind border below the end of the sixth vein, filling up almost the whole of the axillary lobe, and being thus broadly united to the basal blackish part; the whole of the first basal cell, and the base of the discoidal and third posterior cells are broadly united with this band. The marginal band is broadly united at base with the basal one, and does not extend beyond the third vein, passing only a little over it in its terminal part, and ending at costa near the first third of the first posterior cell; it encloses two darker dots in the marginal cell, and two hyaline streaks at costa before and behind the end of the second longitudinal vein. About at middle of the last section of the third vein arises the narrow, but complete and even, middle band, which, crossing beyond the middle of the last portion of the fourth vein, ends at hind border just below the end of this same vein. The oblique cubital band is broader than the middle one, and is broadly united with the basal one at the small cross-vein; it runs along the hind cross-vein, leaving hyaline the upper external corner of the discoidal cell, and ends at hind border symmetrically with the end of the fifth vein. Small cross-vein long and oblique, the first posterior cell being as broad as the discoidal cell, which is very acute below, the hind cross-vein being very oblique. Alula entirely infuscated.

Type ♀, a single specimen from Uganda, Entebbe, 12-13.xii.1912 (C. C. Gowdey).

**Xanthorrhachista**, Hendel, 1914.**Xanthorrhachista alata**, Becker, 1910.

In my previous paper I overlooked the description of *Acidia alata*, Beck. (Ann. Soc. Ent. France, 1910, p. 28), with which *Xanthorrhachista cephalia*, Hend. (1914), is undoubtedly synonymous.

**Themarictera**, Hendel, 1914.

To the characters of the genus on p. 243 of the first paper must be added :

No *oc.* ; two pairs of *vt.* ; two *s. or.* and two *i. or.* ; *pvt.* well developed ; genal bristle thin ; *ocp.* long and acute, black. *Scp.* long, the middle ones approximated ; no *pt.* ; *st.* very short and thin, not properly wanting, as stated by Hendel ; three *p. sa.*, the inner one thinner.

**Themarictera laticeps**, Loew, 1861.

Closely allied to *T. flaveolata*, F., but differing in the presence of two hyaline spots, one in the submarginal and one in the first basal cell. The first of these spots is placed on the limit between the brown and the yellow pattern, beginning at the third longitudinal vein just beyond the small cross-vein, and extending above nearly to the middle curve of the second vein ; in this way is formed the black indentation, which is exaggerated in Loew's original figure. The second hyaline spot is before the small cross-vein ; it is ovate in shape, and extends from the third to the fourth vein. These two spots are distinctly whitish, like the basal streaks, as described by Loew. In the rest the unknown male is very like the female ; the genitalia are rounded, not prominent, entirely shining yellow ; the last abdominal segment has numerous black bristles. The eyes are green, with two purplish cross bands, converging anteriorly, on the upper half.

A male specimen from Natal, Durban, xi.1916 "reared from native fruit" (*C. P. van der Merwe*, Agric. Dept. S. Africa). This specimen is an aberrant one, or is not fully coloured in the wing pattern, hyaline streaks being present in the ends of the marginal, submarginal and discoidal cells and the whole middle of the first posterior cell ; the fuscous pattern is thus restricted to some broad borders on the longitudinal and cross-veins.

*Puparium.* To the reared specimen is attached a puparium, which seems to be rather small for such a fly ; it measures 6 mm. only in length, while the adult fly is about 9 mm. long. It is of a dark reddish-brown colour and has a rather hard and thick skin ; the segmentation lines are not impressed ; the broadened areas of the ventral side are not prominent ; the posterior spiracles are very approximated, the surrounding parts being of a blackish colour. The surface is smooth, but quite opaque.

**Rhacochlaena**, Loew, 1862.

The Ethiopian species of the present genus, with the addition of the new one, may be distinguished as follows :

- 1(2). Wings destitute of a broad apical fuscous band, the first and second posterior cells being almost completely hyaline .. .. . *fasciolata*, Lw.



- 2(1). Wings with a broad fuscous apical band, the first and second posterior cells being for the greater part infuscated.
- 3(4). Apical hyaline spot of the wings broad, extending on both sides beyond the ends of the 3rd and 4th veins .. .. . *pulchella*, sp. n.
- 4(3). Apical hyaline spot small and not extending laterally beyond the ends of the above-named veins .. .. . *hammersteini*, End.

***Rhacochlaena fasciolata*, Loew, 1863.**

The apex of the wing is occupied by a white rounded spot, which in certain lights is very conspicuous. The ovipositor is 2 mm. long; it is cylindro-conical, shining red, but broadly black at base above and more narrowly at tip; it is clothed with very short and dense, darkish pubescence. In the present species there is but a single s. or.

A couple of specimens from Natal, Estcourt, ix. and x. 1896 (*G. A. K. Marshall*).

***Rhacochlaena pulchella*, sp. nov. (Pl. xvii, fig. 8).**

Very near *hammersteini*, but at once distinguished by the much broader apical hyaline spot of the wings.

♂. Length of body 4·5 mm.; of wing 4 mm. Head reddish, face jowls and lower part of occiput pale yellowish or whitish; frons opaque, with shining vertical plates and slightly whitish sides; the small ocellar dot is black. In the middle of the face there is an ill-defined fuscous cross band, not reaching the sides. Antennae entirely reddish, but the third joint a little infuscated at the end; the third joint is rather narrow, with the upper border distinctly concave; it is  $2\frac{1}{2}$  times as long as broad, with rounded tip; arista shortly pubescent. Jowls very narrow, narrower than the breadth of the third antennal joint. Eyes greenish, with two parallel cross bands of a purplish colour, one a little beneath the middle, the other on the upper third. Palpi and proboscis yellowish. Cephalic bristles black; or. 1 + 3; no oc.; pvt. less developed; the longer bristles are rather yellowish at the end. Thorax black, opaque, with greyish dust on the back; a middle longitudinal stripe and the sides are reddish; pleurae shining yellowish; along the notopleural line, from the humeri to the root of the wings, there is a rather broad whitish stripe. Scutellum whitish in the middle and infuscated on the sides. Mesophragma black and a little shining; the hypopleurae are also black, but with a narrow whitish stripe in continuation with the notopleural one. Squamulae and halteres whitish. Chaetotaxy typical; all the bristles are black, but the longer ones have yellowish ends; four scutellar; the short pubescence is pale yellowish. Abdomen black, with the last segment reddish brown behind, rather shining, with dark pubescence and black terminal bristles. Genitalia reddish brown, shining, with short yellowish appendages beneath. Legs entirely yellowish; bristles of front femora and spurs of middle tibiae black. Wings nearly the same as in Enderlein's fig. R, p. 441, with the following differences: (a) the first fuscous band is less developed and much shorter, ending near the upper corner of the second basal cell; (b) the second fuscous band is longer, reaching the hind border of the wing or nearly so; (c) the third abbreviated band is narrower; (d) the apical hyaline spot is twice as broad, extending symmetrically above in



the submarginal and below in the second posterior cell ; it is distinctly whitish ; (e) the hyaline indentation into the second posterior cell is narrower ; (f) the hyaline dot at the end of the second longitudinal vein and the hyaline streak in the middle of the first posterior cell are faintly developed, or even indistinct.

Type ♂, a single specimen from the Gold Coast, Acera, i. 1916 (Dr. J. W. S. Macfie).

\* \* \* \* \*

The Ethiopian species referred by authors to *Acidia*, were provisionally placed by me under the head of *Philophylla* ; but after the removal of *obnubila* and *coloniarum* to *Celidodacus*, there remain only *ocellata* (which belongs to a new genus) and *seychellarum*, which on account of its eyes certainly cannot be ascribed to *Philophylla*. This last genus seems therefore to be absent from the Ethiopian fauna. The genera of this group must be disposed as follows, with a modification of my table on pp. 218-219 of the first paper.

43(42). *Prst.* always present ; two *s. or.*

44(45). Small cross-vein near or before the middle of the discoidal cell.

a(b). Wings of usual shape, with straight costa and long second posterior cell, adorned with narrow vertical fuscous bands, which are often partly broken into spots . . . . . *Phorellia*, R. D.

b(a). Wings towards the middle very broad, with the costa rounded outwardly and with very short second posterior cell ; they are adorned with a broad rounded fuscous patch and with some curved dark bands  
*Taomyia*, gen. nov.

45(44). Small cross-vein beyond the middle of the discoidal cell, and often very near the hind cross-vein.

c(f). Eyes in profile narrow, much higher than broad.

d(e). Occipital lower swellings not developed ; wings with yellow longitudinal stripes, the lower one bifurcate at end ; thorax with black spots  
*Notomma*, gen. nov.

e(d). Occipital lower swellings rather developed ; wings with yellowish or fuscous, partly confluent, cross bands ; thorax not black-spotted  
*Philophylla*, Rond.

f(c). Eyes in profile broad and rounded ; if they are rather narrow, the occipital lower swellings are not developed.

g(h). Wings of usual shape, with short stigma and distinct costal bristle ; *oc.* well developed ; wings banded, at least on the apical half *Acidia*, R. D.

h(g). Wings rather narrow, with parallel sides, with elongate stigma and without costal bristle ; *oc.* very thin or even wanting ; wings not banded, with the fore half usually entirely infuscated . . . *Ocneros*, O. G. Costa.

#### *Taomyia*, gen. nov.

The present new genus is nearly allied to *Acidia* and *Philophylla*, differing from both in the very different shape and venation of the wings, which recall that of the Neotropical genus *Parastenopa*, Hendel, which however has no *oc.* and a differently shaped pterostigma. Head in front view a little higher than broad, in side view

with rather narrow eyes and distinct lower occipital swellings. Frons as broad as the eye, distinctly longer than broad, flat, with very short orbital plates; lunula broad. Face shorter than the frons, convex in the middle, with no prominent upper mouth-border and with diverging antennal grooves; cheeks linear; jowls narrow. Antennae inserted a little below the middle of the eyes, rather separated at base, shorter than the face; second joint less prominent above and not spinulose; third joint linear, twice as long as the basal ones, rounded at tip; arista quite bare. Palpi not very broad, bristly; proboscis short. *Ocp.* black and acute, less numerous; *oc.* very long and strong; one *s. or.*; 2 or 3 *i. or.*, only the middle pair being long, the other very short; genal bristle well developed. Thorax elongated, about twice as long as broad, with complete chaetotaxy, but the middle *scp.* are not developed; *dc.* placed much behind the line of the *a. sa.*; one *mpl.*; *pl.* rather thin. Thoracic suture broadly interrupted in the middle. Scutellum bluntly triangular, convex above, bare, with four bristles, those of the apical pair decussate at the end. Abdomen oval, elongate, not broader than the thorax, with terminal bristles; male genitalia prominent and appendiculate. Legs rather slender; front femora with 5 bristles below; middle tibiae with one spur; hind tibiae with only 4-5 longer bristles on the middle of the outer side. Wings of usual shape in the basal half, very broad and nearly semicircular in the apical half, broadly infuscated, with hyaline stripes, surrounding a large rounded middle patch. Costa very curved on its last portion; costal bristle hardly distinguishable; first vein not specially curved upwards at the end, the stigma being longer than broad; second vein straight; third vein bristly to the middle of its last portion, which is strongly curved downwards towards the end, and thus very divergent from the second and parallel with the last portion of the fourth; submarginal cell very widened at end; discoidal cell very long and much broadened outwardly, the hind cross-vein being perpendicular, arched outwardly, about three times as long as the basal cross-vein of the discoidal cell, and about as long as the terminal portion of the fourth vein; small cross-vein on or just beyond the middle of the discoidal cell; second posterior cell unusually short, higher than long; lower angle of the anal cell drawn out into an acute point, which is shorter than the second basal cell; axillary lobe broad; alula well developed and rounded.

Type: the following new species.

It is very probable that *Acidia* (?) *ocellata*, Lamb, 1914, from the Seychelles, belongs to the present genus, having a similarly formed head and a very similar wing pattern; but it has the small cross-vein placed beyond the middle of the discoidal cell, and two *s. or.* on the frons.

**Taomyia marshalli**, sp. nov. (Pl. xvii, fig. 9).

A very distinct fly of comparatively large size, at once distinguishable on account of its very characteristic wings.

♂. Length of body 7.5 mm.; of wing 7 mm.; breadth of a wing 3.2 mm.

Head of a dark reddish-brown colour; occiput shining, broadly blackened on the sides, light yellowish near the eye-borders and below; frons rather shining, with a blackish ocellar dot and an ill-defined blackish transverse band in front above the antennae; lunula shining yellowish; face shining, dark brown in the middle, more

yellowish towards the antennal grooves and on the sides; cheeks whitish; jowls unspotted. Antennae entirely pale yellowish, the third joint a little infuscated along the upper border; arista pale yellowish at base. Palpi yellowish; proboscis dirty brownish. All the cephalic bristles are black and rather thin; the frontal stripe seems to be bare on the middle. Thorax black on the back, but clothed with greyish dust and with three narrow parallel longitudinal black stripes, those on the dorsocentral lines extending about to the scutellum, while the middle one is abbreviated behind the transverse suture. The short pubescence of the back is black. The shoulders, the notopleural suture and the postalar calli are reddish brown, like the pleurae, which are blackened on the middle of the meso- and sternopleura, but are pale yellowish on the pteropleura, forming thus a broad perpendicular stripe; hypopleura blackish and shining, like the postscutellum and the mesopleuragium. Scutellum entirely yellowish with a narrow black basal band. All the thoracic bristles are black and rather thin. Squamulae dirty brownish; halteres pale yellowish. Abdomen black, shining, but with dark dust; pubescence and bristles black; genitalia yellow, black above and behind; the unpaired and strong appendage of the underside is similarly yellow. Legs pale yellowish, but the four posterior femora above on the apical half, and all the tibiae except the tip, are more or less blackened; bristles black, those of the front femora very thin. Wings whitish hyaline, with a very broad, dark brown pattern; an abbreviated stripe, extending from the middle of the stigma to the third longitudinal vein is yellow. Veins yellow, but darkened on the dark parts. Costal bristle very small. Extreme base of the wing hyaline; an arcuate brown band begins along the costa, filling up the whole of the first and the base of the second costal cell, and becoming gradually broader passes over the middle of the second basal cell, fills up the whole of the anal cell and is prolonged as an acute stripe along the sixth longitudinal vein, ending with a point at the hind border of the wing. The axillary lobe and the alula are quite hyaline. After this dark band there is a narrow, complete hyaline band, going from the middle of the second costal cell, over the apex of the second basal cell and over the base of the third posterior cell, to the hind border of the wing. The extensive brown pattern of the broadened apical half of the wing is thus sharply separated from the basal one; it consists of a rounded, very broad patch, which occupies the whole of the discoidal cell, and the greater part of the submarginal and first basal cells, and the entire third posterior cell. At the fore border there is the yellow stigmatic indentation, and after this a broader triangular oblique hyaline indentation, which reaches with its obtuse point the fourth vein, entering the end of the first basal cell; from this indentation departs a rather narrow hyaline arcuate band, which, running along the fore border, from which it is separated by a narrower brown costal band, ends in the upper angle of the second posterior cell. The yellow stigma is blackish brown at base and on the lower spical half.

Type ♂, a single specimen from Natal, Verulam, vii. 1897, collected by *Dr. G. A. K. Marshall*, in whose honour this fine insect is named.

### **Notomma**, gen. nov.

The present genus is erected here for a species which has a wing pattern recalling that of *Xanthorrhachista*, from which it differs in general appearance and in the



position of the small cross-vein, and *Craspedoxantha*, from which it differs in the bristly third longitudinal vein and in the position of the *dc.* bristles. In Prof. Hendel's table it runs down to *Neanomoea*, an undescribed Oriental genus from Formosa.

*Trypeta jucunda*, Loew, seems to be an allied form, but differs in the venation and in the shape of head, belonging probably to some peculiar, as yet undescribed genus.

Head a little narrower than the thorax, in front view about as broad as high, in profile rather flat, the eyes being narrow, with the vertical diameter about twice as long as the horizontal. Occiput flat, even a little convex on the upper half, destitute of distinct lower swellings. Frons gradually narrowed from the vertex to the antennae, flat, narrower than one eye in front, about one and a half times as long as broad, in profile a little prominent above the base of the antennae. Lunula broad. Eyes greenish, with a purplish horizontal band just above the middle. Face flat, with a distinct, broad and rounded middle keel and with shallow antennal grooves; mouth-border prominent; cheeks linear; jowls narrower than the breadth of the third antennal joint. Antennae inserted a little above the middle of the eyes; second joint short, small, bristly above; third joint broad, pubescent, parallel-sided, rounded at tip, not reaching the mouth, less than twice as long as broad; arista bare. Palpi broad, bristly; proboscis short and thick. Cephalic chaetotaxy complete and well developed; *ocp.* acute, black; *pvt.* thin and parallel; two pairs of *vt.*, the inner ones not much longer; *oc.* robust but not long; two *s. or.* and three *i. or.*; genal bristle strong, like the bristle on the lower part of the occiput. Thorax robust, flat, subquadrate, with complete chaetotaxy; the middle *sep.* are approximated and as long as the outer ones; *a. sa.* strong; *dc.* placed much behind the line of the *a. sa.*; *prsc.* approximated; two *mpl.*; *pt.* about as strong as the *st.* Scutellum convex above somewhat *Ceratitis*-like in shape but not trilobate, with four strong bristles, the apical ones diverging. Abdomen in the middle broader than the thorax, narrowed at base and at the end: it has five segments, the last with bristles at the sides and behind; ovipositor elongate triangular, rather swollen. Legs short and stout; front femora with a complete row of strong bristles beneath; middle tibiae with one spur; hind tibiae with a complete row at the outer side; claws curved; middle tibiae without bristles on the hind side. Wings elongated and proportionally narrow; costa not ciliated and without costal bristle. They are adorned with two longitudinal yellow bands, one along the fore border and the other along the middle; this last is bifurcate into a recurrent band across the hind cross-vein and along the hind border of the wing. Auxiliary vein strong; first longitudinal vein long, ending beyond the middle of the wing but always before the small cross-vein; stigma long, in the middle about three times as long as broad; second and third veins rather approximated, slightly sinuous, the third bristly throughout its whole length; the last portion of the fourth vein is slightly sinuous and nearly parallel with the last portion of the third, which ends nearer the tip of the wing, but the first posterior cell is much broader at end than at base; small cross-vein placed exceedingly near the end of the discoidal cell, its distance from the hind one being about equal to its own length; hind cross-vein curved and oblique outwardly, its lower end



being very near the hind border of the wing; discoidal cell very broad at end; second posterior cell very short, above only a little longer than broad at base; second basal cell rather broad and short; anal cell with the lower angle acute and prolonged, but not longer than the second basal cell; sixth vein reaching the hind border of the wing. Axillary lobe broad and short; alula rounded.

Type: the following new species.

**Notomma bioculatum**, sp. nov. (Pl. xvii, fig. 10).

A reddish brown species, with two deep black spots on the middle of the back of the mesonotum.

♀. Length of body 6.5 mm.; of wing 6.5 mm.; of ovipositor 1.5 mm.

Head entirely yellowish, with only a small black dot on the ocelli. Occiput shining, on the lower part with faint pale dust and with some rather long and soft pale hairs. Frons opaque, with shining ocellar and vertical plates and some scattered dark hairs on the middle. Face with whitish dust. Antennae entirely yellowish, even the arista; palpi and proboscis yellowish, the latter with dirty blackish flaps. All the cephalic bristles are black. Thorax reddish brown, shining on the back; it is clothed with faint greyish dust and short black pubescence, disposed in regular approximate longitudinal rows; the two very striking, deep black, opaque spots are of oval shape and placed on the dorsocentral lines, just behind the suture; the pleurae are paler and more shining, and clothed with rather long, scattered black hairs. Scutellum coloured and pubescent like the back of the mesonotum; at hind border it has three ill-defined, shining brown spots, a smaller one between the apical pair of bristles, and a larger one on each side between the basal and apical pairs of bristles. All the bristles are black. Squamulae reddish, with a dark fringe; halteres reddish yellow. Postscutellum reddish, with two rounded black spots; mesophragma entirely of a shining reddish colour. Abdomen shining reddish, with black pubescence and black bristles; the hind border of the segments is more lightly coloured; the venter likewise; ovipositor shining reddish. Legs entirely reddish, with paler tibiae and tarsi; bristles and spurs black. Wings shining and iridescent with yellowish veins. The first yellowish band is complete from the base to the tip of the wing, going throughout along the costa, but leaving two hyaline streaks in the marginal and submarginal cells, just before and behind the end of the second longitudinal vein; in the middle this band does not extend below the second vein, while at base it reaches the fourth vein just above the second basal cell, and at the end it extends below the third vein to the middle of the end of the second posterior cell; at the end there is a blackish infuscation, on both sides of the apex of the third longitudinal vein; in the middle of the marginal cell there is a black rounded spot, just beyond the entirely yellow stigma. The second longitudinal band is of a paler yellowish colour above, but infuscated below and at the end; it begins on the anal cell and on the lower part of the second basal cell, and goes across the base of the discoidal and the apex of the first basal cell to the small cross-vein; it there becomes narrower and is bent downwards, going along the last portion of the fourth vein to the costa, which is reached just below the tip of the fourth vein itself. From this band arises another, which forms a border along the hind cross-vein and extends beyond it as a border along

the hind border of the wing to the end of the sixth vein; this recurrent band is yellowish interiorly and fuscous exteriorly. The hyaline band between these two yellow longitudinal bands is nearly equal in breadth throughout its whole length and is bent just above the small cross-vein, entering there as a small streak into the marginal cell, below and before the rounded black spot of the fore border. The hyaline band between the central yellow band and the recurrent posterior band ends with a rounded tip in the base of the first posterior cell just behind the small cross-vein; at base this band is united with the hyaline axillary lobe. The second basal cell is almost entirely hyaline, while the discoidal and third posterior cells are almost entirely infuscated except the broad hyaline band mentioned above.

Type ♀, a single specimen from the Gold Coast, Aburi, 1912-13 (*W. H. Patterson*).

### ***Acidia*, Rob.-Desv., 1830.**

Three species are provisionally placed in the present genus, those here described as new being very like the European *A. caesio*; they may be distinguished as follows:—

- 1(4). Discoidal and third posterior cells with hyaline streaks or spots.
- 2(3). Thorax and femora black; the apical dark bands of the wing broadly united with the basal patch, the second hyaline indentation of the fore border being quite wanting; discoidal and third posterior cells each with a hyaline rounded spot .. .. . *seychellensis*, Lamb.
- 3(2). Thorax and femora entirely yellow; the apical dark bands quite separated from the basal pattern by the second indentation, which forms a complete hyaline cross-band; discoidal and third posterior cells, each with a hyaline streak .. .. . *fossataeformis*, sp. n.
- 4(1). The above-named cells entirely fuscous and destitute of hyaline parts; body and femora entirely black; wings with two hyaline indentations at fore border .. .. . *homogenea*, sp. n.

### ***Acidia fossataeformis*, sp. nov. (Pl. xviii, fig. 1).**

An elegant species very like the Oriental *A. fossata*, F., but at once distinguished by its entirely yellow thorax and legs.

♂ ♀. Length of body 4·5-5 mm.; of wing 4-4·5 mm.; of ovipositor 0·8 mm.

Head entirely yellow and unspotted, except the very small black ocellar dot. Occiput flat on the upper half, even a little concave above the median tubercle, convex but not very prominent on the lower half, without distinct swellings. Frons reddish yellow, opaque, with scattered dark hairs and moderately shining vertical plates; it is parallel-sided, narrower than the eye,  $2\frac{1}{2}$  times as long as broad; lunula broad and short, semicircular, whitish, with brown upper border. In profile the frons is only a little prominent above the antennae; the eyes are rather rounded, their vertical diameter being only a little longer than the horizontal. Face flat and long, not prominent at mouth-border, with a broad middle keel and not very deep antennal grooves; cheeks linear, whitish; jowls whitish, unspotted, as broad as the breadth of the third antennal joint. Antennae entirely yellow, inserted at the middle of the eyes, short, extending only to the middle of the face; second joint swollen and prominent, with a short bristle above; third joint rather

small, short, attenuated apically but with rounded tip; arista with rather long pubescence, but the breadth of feathering narrower than the breadth of the third antennal joint. Palpi and proboscis short, yellowish, pale-haired. All the cephalic bristles are black and rather thin; *ocp.* well developed and acute; *pvt.* parallel; outer *vt.* half as long as the inner ones; *oc.* short and thin; two *s. or.* and three *i. or.*; genal bristle well developed. Thorax reddish yellow on the back, very little shining, with faint whitish dust and short dark pubescence; the pleurae are paler and more shining, with scattered longer dark hairs. All the bristles are black; chaetotaxy complete; *scp.* well developed, the middle ones approximated; *dc.* placed much behind the line of the *a. sa.* and near to the *prset.*; only one strong *mpl.*; *pt.* as strong as the *st.* Scutellum triangular, as long as broad, flat above, with lateral keels; it is coloured like the back of the mesonotum, but is more bare and shining; it has four black bristles, the apical ones being shorter and decussate. Squamulae and haltetes pale yellowish; the former with a short thin white fringe. Postscutellum and mesophragma entirely reddish yellow and shining. Abdomen of usual shape, as broad as the thorax towards the middle; it is shining reddish yellow, but sometimes very infuscated in the male and even brownish or blackish; the pubescence and terminal bristles are black; venter more yellowish, with faint pale dust. Male genitalia shaped as in *fossata*, with a pair of long and stout appendages, the basal one reddish, while the apical one is black, and longer and stouter. Ovipositor with the basal segment broadly triangular, shining black, the apical segment narrow and dark reddish; the contrast between the reddish abdomen and the black ovipositor is very striking. Legs rather slender, entirely yellowish; front femora with 3-4 long black bristles beneath at the end; middle tibiae without bristles, with one black spur at the end; hind tibiae with no distinct row. Wings shining and iridescent, with non-ciliated costa and with a short but distinct costal bristle. The veins are yellowish at base and on the hyaline parts, black on the rest; the second longitudinal vein is a little sinuous; the third vein is bristly throughout its whole length; the second, third and fourth veins are equally divergent towards the apex, ending at equal distances; the last portion of the fourth vein is straight; the small cross-vein is placed beyond the middle of the discoidal cell; the hind cross-vein is straight, perpendicular, a little longer than its distance from the small one; inferior angle of the anal cell produced, long and narrow, but not longer than the second basal cell; sixth longitudinal vein complete. The base of the wing is yellowish in the basal and costal cells, even the brown stigma being yellow at base. The pattern is blackish brown and about the same as in *fossata* (*vide* Bezzi, Mem. Ind. Mus., iii, 1913, pl. ix, fig. 48), which however has the wings distinctly broader.

Type ♂, type ♀, and some additional specimens of both sexes from Nyasaland, Chiromo, Ruw R., 2.i.1917 (*R. C. Wood*).

### ***Acidia homogenea*, sp. nov.**

A black species, with a wing pattern very like that of the European *A. caesio*, but at once distinguished from it and from the other species by the discoidal and third posterior cells being completely infuscated, without hyaline spots or streaks.

♀. Length of body 4 mm.; of wing 4 mm.; of ovipositor 0.6 mm.



Entirely shining black, the head, antennae, tibiae and tarsi in part yellowish or whitish. Head as broad as the thorax, rounded in front view and about as high as broad; it is rather narrow in lateral view, the eyes being considerably higher than broad. Occiput entirely black, shining above, grey-dusted below, without lower swellings; it is narrowly reddish on its lower portion. Frons narrow and long, parallel-sided, narrower than the eye, twice as long as broad; it is entirely reddish, opaque, with shining white sides, and with a small blackish ocellar dot, the narrow and short vertical plates are shining; lunula broad, semicircular, whitish. Antennae inserted near the middle of the eyes; the two basal joints are yellowish; third joint wanting in the type. Face only a little shorter than the frons, as broad as it above, but twice as broad below; it is flat, with shallow antennal grooves, and no prominent mouth-border; it is blackish, with a shining white dust, yellowish only on the flat middle keel; cheeks linear, hardly distinguishable; jowls very narrow, reddish, unspotted. Palpi and proboscis dirty yellowish, the former dilated at the end, the latter short and thick. Cephalic bristles missing in the type, but judging by the insertion points there are two *s. or.* and three equally distant *i. or.* Thorax entirely shining black, not dusted on the back; scutellum similar, triangular, flat above; pubescence and bristles abraded in the type, but the *mpl.* and *st.* are present on one side and are black; the scutellum has certainly four bristles; the *dc.* are placed very near the suture. Squamulae brownish; halteres black. Abdomen entirely shining black, with short black pubescence and black bristles at the end; ovipositor shining black, triangular, flat, proportionally short; apical segment reddish; venter black. Legs with shining black femora; front tibiae entirely, four posterior ones on the apical half, whitish, like the whole of the tarsi. Wings rather broad, with the membrane shining and iridescent, chiefly on the hyaline parts; costa and veins black, but whitish on the hyaline parts. First longitudinal vein short, the stigma being about as long as broad at base; second vein straight; third vein bristly to the small cross-vein, bent downwards beyond middle of its last portion; last portion of the fourth vein curved and slightly diverging from the third; small cross-vein beyond the middle of the discoidal cell; hind cross-vein straight and perpendicular, a little longer than its distance from the small one; lower angle of the anal cell narrow and shortly produced. The blackish pattern is very like that of *A. caesio*, or of the Formosan "*Trypeta*" *superflucta*, End. (Zool. Jahrb. xxxi, 1911, p. 428, fig. J); but it differs in having more than the basal half of the wing entirely blackish, without any hyaline indentation of the fore border before the stigma, and without any hyaline spot or streak in the discoidal or third posterior cells; only the axillary lobe is hyaline. The stigma is deeper black than the surrounding parts. The first hyaline indentation of the fore border beyond the stigma is as in *caesio*; the second likewise, but ending with a narrow point on the fourth longitudinal vein, without entering the discoidal cell. The two hyaline apical indentations of the hind border are as in *caesio*, the black streak between them being complete and not interrupted at base (differing thus from that of *fossata* and *fossataeformis*, in which it is isolated).

Type ♀, a single specimen from Nyasaland, Port Herald, iv-vi. 1913 (*Dr. J. E. S. Old*).



**Ocneros**, O. G. Costa, 1844.

In the typical species of the present genus the *dc.* are placed near the suture, while in the known Ethiopian species they are placed much behind. It seems thus probable that the latter species are not congeneric with the palaearctic ones; but I have not erected a special genus for them, because they may perhaps be better placed in the following genus *Ocnerioxa*, which differs only in the non-bristly third longitudinal vein.

The genus seems to be abundantly represented in the Ethiopian fauna; I have before me two additional new species, which belong to the group of *O. sinuatus*. This group is not only distinguished by its colour characters, but also by the slender body, the longer antennae (which are nearly extended to the mouth-border), the distinctly pubescent arista, the thin and prevalently yellow macrochaetae of the head, thorax and scutellum, the longer pterostigma, and by the last portion of fourth longitudinal vein being quite straight. To the characters of the genus must be added that the *i. or.* are accompanied by additional bristly hairs.

The known species may be distinguished, by a modification of the table on p. 250 of my first paper, as follows:—

1(2). Scutellum entirely yellow; discoidal cell wholly infuscated, without hyaline spots; stigma as long as or longer than the second costal cell; antennae about as long as the face, with a shortly pubescent arista; macrochaetae mostly yellow.

*a(d)*. Base of stigma narrowly hyaline, at least near the costa; there is a small hyaline dot in the base of the first posterior cell, just above the hind cross-vein.

*b(c)*. Hyaline spot in the marginal cell beyond the stigma triangular and extended to the second longitudinal vein; the fuscous portion of the wing has below only a median broad projection, which extends about to the hind border in the hyaline part of the wing .. .. *sinuatus*, Loew.

*c(b)*. Hyaline spot of the marginal cell in the shape of an elongate stripe near the costa, which does not extend below beyond the middle of the cell; the fuscous portion is wavy below, with 4-5 projections, which are all far from the hind border of wing .. .. *undatus*, sp. n.

*d(a)*. Base of stigma with a broad hyaline spot; no hyaline dot in the base of the first posterior cell; fuscous part of wing ending below with one acute median projection, which reaches the hind border of wing along the fifth vein.. .. *bigemmat*, sp. n.

2(1). Scutellum broadly black in the middle; discoidal cell with hyaline spots; stigma shorter than the second costal cell; antennae much shorter than the face, with bare arista; macrochaetae black *mundus* and *excellens*.

**Ocneros undatus**, sp. nov.

A slender and pale-coloured species of smaller size, very distinct on account of the lower border of the fuscous part of the wing being wavy and remote from the hind border of the wing.

♀. Length of body 4 mm.; of ovipositor 1 mm.; of wing 4.5 mm.

Head entirely yellow and opaque; occiput with a narrow black stripe on each side, extending from the neck to the lower third of the eyes; frons narrower than the eye and longer than broad, unicolorous, with a very small black ocellar dot. The face and unspotted jowls are yellowish, while the occipital lower swellings are more lightly coloured and surrounded above with the black stripe; upper mouth-border prominent. Antennae entirely pale yellowish, only a little shorter than the face, with the third joint rather broad, and with a shortly pubescent arista. Palpi and proboscis pale yellowish. All the cephalic bristles are pale yellowish, only the short outer *vt.*, the acute and numerous *ocp.* and the *i. or.* being black; there are no distinct ocellar bristles; there are only two pairs of longer *i. or.*, but on the same line are some black, much shorter, bristly hairs. The lower occipital hairs are whitish; the bristly hairs near the borders of the mouth are yellowish. Thorax entirely yellowish, less shining, with pale short golden-yellowish pubescence; on each side there are two black longitudinal stripes, one extending from the shoulders along the notopleural line to the root of the wing, and continuous with the black postalar calli and the very glistening black mesophragma; the other is parallel with the former but ends at the suture, being continued beyond it only by a short ill-defined darkish stripe; the occipital black stripe is continuous with the notopleural one. The pleurae and the breast are entirely whitish yellow, unspotted, the contrast between the black and the whitish parts being very striking, when the thorax is viewed from the side. Hypopleural spot whitish. Scutellum of a light yellowish colour, like the posterior part of the back of the mesonotum, but a little more shining. Postscutellum shining black. All the macrochaetae are yellowish, those of the pleurae being lighter; one *mpl.*; *pt.* much weaker than the *st.*; even the *scp.* are black. Squamulae blackish, with a long dark fringe; halteres pale yellowish. Abdomen shining yellow on the basal half, blackened on the apical half, the last three segments having black lateral borders; venter whitish; hairs and bristles yellowish. Ovipositor flattened, broadly obtuse at the end, shining reddish with pale pubescence. Legs entirely whitish yellow, those of the front pair wanting in the type; apical spur of the middle tibiae black; hairs of the posterior row of the hind tibiae brownish. The wings are almost wholly and evenly infuscated; the lower border of the fuscous part ends about on a line extending from the point of the anal cell to the lower anterior corner of the discoidal and the upper third of the second posterior cell; but this line is wavy, having some rounded projections, three of which are in the second and three in the third posterior cell. There is besides a very small subhyaline rounded dot in the basal part of the first posterior cell, a little before the hind cross-vein and closer to the fourth than to the third longitudinal vein. The stigma is as long as the second costal cell and is black, with a narrow short subhyaline streak near the base at costa, being as broad as a third only of the stigma itself. The hyaline streak at fore border beyond the stigma is shorter than the stigma itself, and does not extend below beyond the middle of the marginal cell. The small alula is entirely brown, while the axillary lobe is entirely hyaline. The third longitudinal vein has 2-3 bristles beyond the small cross-vein. The last portions of the third and fourth longitudinal veins are quite straight and parallel, or only a little divergent.

Type ♀, a single specimen from Nyasaland, Mt. Mlanje, 2.iii.1913 (*S. A. Neave*).

**Ocneros bigemmatum**, sp. nov. (Pl. xviii, fig. 2).

Very like the preceding species, but distinguished by its larger size, and the different pattern of the thorax and wings.

♀. Length of body 5.5 mm. ; of ovipositor 1 mm. ; of wings 6 mm.

Head, its appendages and bristles exactly as in the preceding species ; the two occipital black spots are broader, shaped as a triangular patch, the outer corner of which does not reach the border of the eyes ; there are besides two approximated black stripes above the neck, directed towards the vertex, wanting in *O. undatus*. Thorax and scutellum, and their pubescence and bristles, exactly as in the preceding species ; there is also an equally narrow, black, notopleural stripe in continuation of the occipital one, and therefore there is the same striking contrast with the whitish pleurae ; the interior stripe is however much broader and ends at the suture, but is continued beyond it with a broad stripe on the dorsocentral lines, extending nearly to the lateral edges of the scutellum. The mesophragma is shining reddish, brownish fuscous on the sides, like the postscutellum. Halteres and squamulae as in *O. undatus*. Abdomen more elongate, shining reddish ; the three terminal segments more broadly black on the sides and middle ; bristles black ; venter darker ; ovipositor shining black, with blackish pubescence. Legs as in the preceding ; front femora with only three rather thin and yellowish bristles on the apical half beneath. Wings as in *O. undatus*, but with the following differences : (a) at base of the stigma there is a broad whitish-hyaline spot, extending below to the first longitudinal vein ; (b) the whitish hyaline spot beyond the stigma has the shape of an oblique band, which goes from the end of the first vein across the middle of the marginal cell to the second vein ; (c) there is no trace of the hyaline basal dot of the first posterior cell ; (d) the lower border of the fuscous part is more irregular, showing a blackish tooth in the middle of the upper border of the third posterior cell, and another more elongate tooth on the outer inferior angle of the discoidal cell, reaching the hind border of the wing along the fifth longitudinal vein ; in the second posterior cell the border of the fuscous part forms a straight line, which has no indentations or projections (or only a little so beyond the fourth vein), the cell being thus mainly hyaline ; along the middle of the anal cell there is also a subhyaline longitudinal stripe, which is wanting in the preceding species.

Type ♀, a single specimen from British East Africa, Embu, 12.xii.1913 (*G. H. J. Orde-Browne*).

**Ocnerioxa**, Speiser, 1915.

The species of the present genus show a great resemblance to those of the first group (*sinuatus*, *undatus* and *bigemmatum*) of *Ocneros* ; they have the same appearance and the same colour pattern of body and wings, being probably congeneric. They can be distinguished only by the third longitudinal vein being quite bare, or scarcely setigerous before the small cross-vein only ; and also by the bare, non-pubescent arista and by the less developed orbital hairs between the fronto-orbital bristles.

In the new material there is the following undescribed form.



**Ocnerioxa discreta**, sp. nov.

Very like *O. woodi* from Nyasaland, but more slender, smaller and distinguished by some minor details in the coloration of the head, abdomen and wings.

♂. Length of body 4 mm. ; of wing 4.5 mm.

The body is narrower than in *woodi*, the thorax measuring about 1 mm. only in breadth, while in *woodi* it is 1.5 mm. broad. Besides there are the following differences : (a) the occiput has only the two lateral black stripes, the two middle ones being quite absent ; (b) the frons is entirely whitish, even above the roots of antennae, the black band of *woodi* being quite wanting, and thus the white lunula is not conspicuous ; (c) the third antennal joint is not at all infuscated ; (d) the black transverse band at the upper mouth-border is reduced to two small spots, one on each side of the mouth-edges, and these spots are moreover dull ; (e) the jowls are entirely whitish, quite destitute of the fuscous subocular spot ; (f) the black notopleural stripe is narrower, and there is a faint indication of an anterior median fuscous stripe, and the mesophragma is dark reddish in the middle ; (g) the abdomen is not at all greenish, and has the fourth segment yellowish, with narrow black sides and hind border ; (h) the wing pattern is identical, but the fuscous tooth below the outer lower angle of the discoidal cell along the fifth longitudinal vein is much shortened, not being extended to the hind border of the wing.

These small differences, together with the very different habitat, may be considered of specific value.

Type ♂, a single specimen from N. Nigeria, Zungeru, 5.xi.1910 (*Dr. J. W. Scott Macfie*).

**Allotrypes**, gen. nov.

This is a rather aberrant genus, which on account of its bare third longitudinal vein, black and strong *ocp.* and its general appearance, comes in the vicinity of *Aciura*, being however very distinct from it in the chaetotactic characters, as well as in the wing pattern.

Head a little broader than the thorax, but in front view about as broad as high. Occiput distinctly concave above the neck, and less prominent below, with the lateral lower swellings but little developed. Frons flat or even a little concave before the lunula, with about parallel sides, as broad as one eye, only a little longer than broad. In profile the frons is not at all prominent, not even above the antennae ; the eyes are rounded, with the vertical diameter only a little longer. Lunula small. Face long, only a little narrower but distinctly a little longer than the frons ; it is about parallel-sided, flat, with no prominent mouth-border, and with shallow but long antennal grooves. Cheeks linear ; jowls very narrow, narrower than the third antennal joint. Antennae inserted distinctly above the middle of the eyes ; they are very short, not extending beyond the middle of the face ; second joint not prominent, shortly setulose above, destitute of long bristles ; third joint pubescent, attenuate at end but obtuse,  $1\frac{1}{2}$  times as long as broad ; arista shortly pubescent. Palpi and proboscis short, retracted into the oral cavity. Cephalic bristles very strong and peculiarly curved ; no distinct *pvt.* ; *ocp.* numerous,



long, unusually strong, black, acute at end; inner *vt.* very long, more than twice as long as the outer ones, strong, curved backwards beyond their middle; one *s. or.* and one *i. or.*, equally strong and long and both curved backwards; the single *i. or.* is placed much in front, near the lunula; *oc.* strong, but not very long; on the sides of frons there are thus only two pairs of bristles, one near the base and one near the end; genal bristle less strong. Thorax proportionally narrow, less convex above, shining on the back, with the suture broadly interrupted. The bristles are strong and the chaetotaxy is complete, except the *scp.*, which are not distinct; *dc.* placed only a little behind the line of the *a. sa.*; *prsc.* only a little closer together than the *dc.*; one *mpl.* only; *pt.* and *st.* very strong, curved upwards. Scutellum triangular, as long as broad, flat above, with distinct lateral keels; it has four bristles, the basal ones very strong and long, the apical shorter, thinner and decussate. Abdomen narrow and elongate, not narrowed at base, with about parallel sides throughout its whole length; it has five segments, the last one with less developed bristles; ovipositor flattened, triangular, about as long as the last three abdominal segments together. Legs proportionally slender and bare; front femora with two long bristles below on the apical fourth; middle tibiae with a single spur; hind tibiae destitute of a distinct row of bristly hairs on the outer side. Wings of usual shape, but rather narrow at base, the axillary lobe being little developed and the alula very narrow. They have a characteristic and rather aberrant pattern (for the group), consisting in a broad infuscation extending almost over the whole wing, with the fore border broadly yellowish-hyaline on a little more than the basal half; there are no hyaline spots, and no hyaline indentations. Costa not ciliated; with a short but strong costal bristle. Auxiliary vein typical, distinct throughout, with diffuse end; stigma short, about as long as broad; first vein hairy and rather short, ending much before the small cross-vein, its distance from the end of the second vein being about twice as long as that of the second from the third vein. Second vein in its last half strongly diverging from the third, which is quite straight throughout and quite bare. Fourth vein straight and parallel with the third; small cross-vein placed beyond the middle of the long discoidal cell; hind cross-vein straight, perpendicular and rather short, being shorter than, or nearly as long as its distance from the small one; last portion of the fifth vein proportionally long and strong; sixth vein complete, but colourless on more than its apical half. Second basal cell but little developed; anal cell broader but shorter than the second basal cell, with an acute but not or very little produced lower angle.

Type: the following new species.

**Alloctypes brevicornis**, sp. nov. (Pl. xviii, fig. 3).

A narrow elongate species not unlike some forms of *Acinura*, but very distinct on account of its wholly testaceous thorax, and its peculiar wing pattern.

♀. Length of body 4.5 mm.; of ovipositor 1.5 mm.; of wing 4.5 mm.

Head reddish above, pale yellowish below; occiput with two broad shining black spots of triangular shape, with the base on the eye-border and the narrow apex reaching the insertion of the neck; these two spots are separated by a yellowish triangle which has the vertex at the neck and the base at the vertical edge.

Ocellar dot small and black. Frons reddish yellow, shining, with sparse short hairs in the middle. Antennae entirely reddish yellow, with the third joint paler. Face pale yellowish, shining in the middle below; the cheeks and jowls are clothed with a faint whitish dust. Palpi and proboscis pale yellowish or whitish. All the cephalic bristles are of a deep black colour. Thorax and scutellum entirely shining testaceous; the back has very short scattered black hairs and no distinct dust; humeri and pleurae paler than the back; all the bristles are black. Mesophragma shining, more or less infuscated in the middle, or even brownish. Halteres and squamulae reddish yellow. Abdomen shining testaceous, distinctly darker than the back of the mesonotum, even blackish brown in the middle of the segments and behind; pubescence and bristles black; ovipositor shining black on the basal half, dark reddish-brown on the apical half, but sometimes entirely black. Legs entirely reddish yellow, with the front tibiae and the front tarsi infuscated; bristles and spurs black. Wings shining, but slightly iridescent; veins and costa yellowish on the light parts, and brownish on the dark ones. Stigma yellowish. The yellowish-hyaline basal part of the pattern extends over the costal, marginal and submarginal cells to the third vein; the marginal cell however has its end brown, while the submarginal cell is brown on its apical half; this clear basomarginal band is yellowish in the middle, being hyaline at the two ends only; sometimes there is a distinct, but not sharply defined, rounded dark spot in the middle of the hyaline part of the marginal cell near the costa (this spot is wanting in the type). The rest of the wing is uniformly brown, only the posterior border of the third posterior cell, of the axillary lobe and of the alula being hyaline; the second posterior cell is somewhat more clear on the middle of its hind border.

Type ♀, a single specimen from Durban, Umbilo, 14.vii.1914 (*L. Bevis*); I have seen an additional specimen from Zululand in the collection of the South African Museum, Capetown.

#### **Aciura**, Rob. Desv., 1830.

Of the present "genus" there are in the new material before me three species, one of which is not yet described and differs from all the others in having all the occipital bristles black, like *binaria*, Loew, which is however a very different species.

#### **Aciura peripicillaris**, sp. nov. (Pl. xviii, fig. 4).

A small elongate slender species, which is allied to *angusta* in having the axillary cell rudimentary, but differs from it and from all the others of the same group in having all the occipital bristles black, and the discoidal cell entirely black with a single hyaline rounded spot near its extreme base.

♂♀. Length of body 3-3.2 mm.; of ovipositor 1.5 mm.; of wing 3.6-4 mm.

Head entirely shining black and very glistening on the occiput, vertex and orbital plates; the very narrow orbits and the linear cheeks are clothed with greyish or whitish dust; the very narrow jowls are dark reddish brown, like the anterior part of the frontal stripe. Lunula very small. Antennae inserted below the middle of the eyes, entirely black; third joint rounded at tip and grey-dusted;

arista long and with rather long pubescence, its feathering being about as broad as the breadth of the third antennal joint. Palpi whitish; proboscis dirty brown. All the cephalic bristles are black, even those of the occipital row; two *s. or.*, the basal one much smaller; three *i. or.*, the apical ones much smaller; *oc.* as developed as the basal pair of the *s. or.*; occipital hairs sparse and black. Thorax narrow and elongate, shining black, more glistening on the sides and on the pleurae; the short and very sparse pubescence of the back is black; all the bristles are black; *dc.* placed before the line of the *a. sa.*; one *mpl.*; *pt.* weaker than the *st.* Scutellum shining black, with only the *b. set.*, which are very long and divergent. Postscutellum and mesophragma shining black like the hypopleural callosities; halteres black; squamulae dark and with a dark fringe. Abdomen narrow and elongate, narrower than but about as long as the thorax; it is shining black, with sparse black pubescence and short black bristles; in the male it is obtuse at the end, the genitalia being shining black and placed inferiorly at the side; in the female the ovipositor is as long as the abdomen, glistening black and with black pubescence, broad at base and acute at end, depressed; the apical segment is dark reddish-brown at base. Venter shining black, with a faint dark grey dust. Legs rather long and slender; they have dark brown coxae and reddish trochanters; the femora are shining black, but narrowly brownish on the sides; the four anterior tibiae are yellow like their tarsi; the hind tibiae are broadly darkened at base, more broadly in the female, and the tarsi are dark yellowish; front femora with 2-3 thin black bristles beneath on the apical half; hind tibiae destitute of a distinct row of bristles on the outer side. Wings very narrow and elongate, with rudimentary axillary lobe and alula, but appearing not so cuneate as in *angusta*, because they are not dilated distally and have a much narrower third posterior cell. The veins are black, but the costa and the first longitudinal are yellow in the two hyaline indentations of the fore border; costal bristle long and strong. The wing pattern is like that of *angusta*, differing chiefly in the presence of two hyaline central spots, and in the indentations of the hind border being more spot-like. The base is entirely hyaline, without the obtuse black band of *angusta*, or only with a faint indication of it below the humeral cross-vein. The stigma is entirely black and about as long as the black apical part of the second costal cell. The two hyaline indentations of the fore border are broader, more regularly triangular and of equal size; the black band between them is broadly triangular and disposed perpendicularly to the costa; the tips of the hyaline indentations are placed exactly on the third vein and are obtuse, but at the upper end of the small cross-vein there is a very narrow short hyaline streak, which is separated from the vertex of the second hyaline indentation. A little before the middle of the first posterior cell there is a rather broad, rounded or shortly oval, hyaline spot as in the following species. The discoidal cell is entirely black, but near its base there is a rounded hyaline dot, which is smaller than the above-named one. The three hyaline indentations of the hind border are very different from those of *angusta*, being much shorter and not produced into the discoidal cell; the two indentations of the third posterior cell have the shape of two rounded spots; the indentation of the second posterior cell is twice as long as the other, but is broad and not stripe-like. The axillary lobe and the alula are hyaline. The third posterior cell is much narrower than



in *angusta*, while the axillary cell is equally narrow; the hind cross-vein is short, nearly straight and perpendicular, the lower outer angle of the discoidal cell being thus not acute and not produced; lower angle of the anal cell not acute.

Type ♂, a single specimen from British East Africa, Embu, 11.iii.1913 (*G. H. J. Orde-Browne*); type ♀, a single specimen from Gold Coast, Aburi, 27.xii.1914 (*Dr. J. W. Scott Macfie*).

***Aciura oborinia*, Walker (1849). (Pl. xviii, fig. 5).**

A comparatively large species, like the following one, but at once distinguished by the hyaline basal spot of the third posterior cell.

I assume the present species to be that of Walker, because it corresponds in the size and answers very well to the description of the wing pattern; but Walker says decidedly that the bristles at hind border of head are black, while in the present specimens they are whitish yellow, like in the following and in the allied species. In this character the species agrees better with the preceding one (*perspicillaris*), which has also the hyaline spot of the first posterior cell; but I think that *perspicillaris* cannot be Walker's species, being much smaller and having a very different wing pattern.

I will give here a short redescription of what I believe to be Walker's species.\*

♂♀. Length of body 4.5–5 mm.; of ovipositor 2 mm.; of wing 5.5–6 mm.

Head reddish brown, with black occiput, black ocellar plate and black vertical plates; antennae with reddish basal joints and infuscated third joint; lunula not specially developed. Thorax shining black, more glistening on the sides and pleurae; the short dorsal pubescence is yellowish; the bristles are black. The scutellum is not well preserved, and seems to have no trace of *a. sc.* Halteres yellowish. Abdomen narrow and elongate, shining black, with black pubescence and black bristles; ovipositor as long as the abdomen, shining black. Legs long and rather slender, black, with the tibiae at end and the tarsi yellowish; front femora with three black bristles beneath. Wings with a rather broad and quite hyaline axillary lobe. The pattern is as described by Walker; the black basal stripe extends from the first costal cell to the middle of the second, ending there obliquely and separated from the black stigma. The second hyaline indentation of the fore border extends with its acute point into the base of the first posterior cell, along the outer side of the small cross-vein; the oval whitish spot at the base of the first posterior cell is placed much before the middle of the cell itself, only a little beyond the upper end of the posterior cross-vein. The three indentations of the hind border are narrow and oblique, the basal one entering the base of the discoidal cell and reaching the fourth vein, while the much shorter middle one enters only with a very short point and the third stops just at the upper basal angle of the second posterior cell. The last portions of the third and fourth longitudinal veins are slightly but distinctly convergent towards the end; the two cross-veins are very close together, their distance on the fourth vein being shorter than the length of the small cross-vein; the hind cross-vein is curved and oblique, the lower exterior angle of the discoidal cell being acute and produced; third posterior cell as broad as the axillary lobe; lower angle of the anal cell rather acute but not produced. Costal bristle long.

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\*[The specimens described by the author agree well with Walker's type.—Ed.]



A couple of specimens from Uganda Protectorate, Entebbe (Forest), 3,800 feet, 5-11.vii.1911 (*S. A. Neave*).

***Aciura tetrachaeta*, Bezzi (1918).**

Of this characteristic species, described from N. W. Rhodesia, there is a couple of specimens from Natal, Estcourt, ix.-x. 1896, and Malvern, 1897 (*G. A. K. Marshall*).

The as yet undescribed male is very like the female; its abdomen is obtuse at the end, and the genitalia are black. The pubescence of the back of the thorax is yellowish, and the bristles are likewise yellowish but more or less infuscated, those of the pleurae being black. The front femora are yellow on the inner side and bear four long bristles beneath. The greyish shade in the middle of the first or basal indentation of the hind border is not distinct in the present specimens.

***Spheniscomyia* Bezzi, 1913.**

I place in this genus a new species, which is rather aberrant in lacking the *a. sct.*; but in size, in the chaetotactic characters of the head, the black *ocp.*, the form of the scutellum and in the faint dust of the thorax, it agrees with the typical species. On account of these characters, it is very different from the Ethiopian species which form the very homogeneous group of *Tephrella* dealt with by me in the preceding paper.

***Spheniscomyia sexmaculata*, Macquart (1843).**

Of this common species there is a male specimen from Nyasaland, Mt. Mlanje, 4.vii.1913 (*S. A. Neave*), and another from Natal, Port Shepstone, v. 1897 (*G. A. K. Marshall*).

***Spheniscomyia neavei*, sp. nov. (Pl. xviii, fig. 6).**

A pretty species very distinct from any other in having no *sct.* and in having two hyaline indentations at the fore border of the wing. It is possible that *A. capensis*, Rond., which is described with a similar wing pattern, belongs to the same natural group as the present species.

♂♀. Length of body 2.3-2.5 mm.; of ovipositor about 1 mm.; of wing 3-3.1 mm.

Ociput entirely black, but clothed with rather dense, dark grey dust; frons reddish, with whitish orbits and black, but densely grey-dusted ocellar and orbital plates; lunula whitish, like the linear cheeks; face yellowish, with whitish dust; jowls very narrow, reddish, not spotted. Antennae entirely reddish yellow, with a shortly pubescent arista. Palpi and proboscis pale yellowish. All the cephalic bristles are black, even those of the occipital row; *oc.* well developed; two strong *i. or.*; genal bristle well developed. Thorax and scutellum entirely black and rather shining, the greyish dust of the back being very faint and even wanting on the scutellum; the bristles are black; *dc.* placed on the line of the *a. sa.*; one *mpl.*; *pt.* above as developed as the *st.*; no *a. sct.*, the *b. sct.* being very long but not diverging. The short pubescence of the back of the mesonotum is black, like the rather sparse hairs of the scutellum. Mesophragma shining black; scutellum broader than long and rather convex. Squamulae white; halteres pale yellowish.

Abdomen shining black, with black pubescence and short black bristles; venter black, but less shining; ovipositor glistening black and with black pubescence. Legs black, with yellow tibiae and tarsi; the femora are narrowly yellowish at tip, and the hind tibiae are infuscated at base; front femora with four long bristles beneath. Wings with long and strong, but simple costal bristle; the veins are black, but they are yellowish at base and on the hyaline indentations. Small cross-vein placed on the apical third of the discoidal cell, which is much broadened outwardly; hind cross-vein convex outwardly; last portions of the third and fourth veins about parallel, the former being only a little curved downwards near the end; lower angle of the anal cell acute, but not produced. The base of the wing is quite hyaline, the dividing line being straight and running obliquely from the distal end of the second costal, second basal and anal cells to the hind border; the stigma is entirely black. At the fore border there are two triangular, hyaline indentations of equal size, just beyond the stigma and reaching with their obtuse point the third longitudinal vein. The wholly black discoidal cell has near its base a rounded hyaline spot, which is above in contact with the fourth vein, while below it is distant from the fifth. At the hind border there are four hyaline indentations, disposed in pairs; two shorter and broader into the third posterior cell, reaching the fifth vein, the basal being twice as broad as the apical one; the other two into the second posterior cell, the basal one extending along the hind cross-vein (but without being in contact with it) to the fourth longitudinal vein; the apical one is curved inwardly and ends broadly obtuse at the third vein, crossing the first posterior cell in its last third. The hyaline parts are distinctly whitish; the dark parts are blackish, only the basal band below the sixth vein in the axillary cell being more greyish.

Type ♂ and type ♀, a couple of specimens from Nyasaland, Mt. Mlanje, 16.vi. 1913; an additional female specimen from the same locality, 31.v.1913, all collected by S. A. Neave, in whose honour this interesting species is named. In the Entomological Museum of the University of Kansas, at Lawrence, Kas., U.S.A., there is a female specimen collected by F. L. Snow at Salisbury, Rhodesia, 5050 ft., v. 1901; it differs in having the basal hyaline spot of the discoidal cell of greater size, extending from the fourth to the fifth longitudinal vein.

**Tephrella, Bezzi, (1913).**

**Tephrella sexfissata, Becker (1910).**

*Aciura sexfissata*, Becker, Ann. Soc. Ent. France, 1910, p. 28.

In my previous paper (Bull. Ent. Res. ix, p. 22) I overlooked this species, which is nearly allied to but distinct from *T. rufiventris*, Bezzi; it is recorded from British East Africa, Nairobi (*de Rothschild*).

IV. Subfam. TRYPANEINAE.

**Spathulina, Rondani, 1856.**

This genus, as defined by me in the preceding paper, seems to have a near ally in the South American genus *Lamproxya*, Hendel (1914, p. 64), which shows also a shining black, not dusted abdomen, but seems to be different in the much more elongate and bicubitate proboscis, in the antennae being inserted below the middle

of eyes, etc.; moreover the type-species, *L. nitidula*, Hendel, from Peru, has a different wing pattern, with more numerous hyaline spots, which are disposed in rows along the longitudinal veins. In the new material there is the following new species, which is the first to be known from West Africa.

***Spathulina bioculata*, sp. nov.**

Closely allied to *semitra* and running down to it in my table (1918, p. 28), but at once distinguished by the pale yellowish macrochaetae of the head and thorax, and by the presence of four (not three) hyaline spots in the second posterior cell, and of two hyaline dots in the first posterior cell.\*

♀. Length of body 2.5 mm.; of ovipositor about 1 mm.; of wing 3.5 mm.

Head not depressed, in front view about as high as broad, in side view narrower than high; it is entirely pale yellowish, more whitish on the face, and blackish but grey-dusted in the middle of the occiput; middle frontal stripe more yellow in the apical half, and there with some scattered yellowish hairs; all the bristles are pale yellowish, those of the hind border quite whitish; there are three *i. or.*, but the apical one is only half as long as the others; *oc.* long and strong; *ocp.* rather acute. Antennae pale yellowish, shorter than the face, with the pubescent third joint as long as the first two joints together and a little pointed at its upper terminal angle; arista microscopically pubescent. The hairs of the lower occipital border and of the chin are whitish. Palpi whitish; proboscis yellow, rather thick, as long as the lower border of the head, with the terminal portion thick, bent backwards and a little shorter than the basal one. Thorax black on the back, but clothed with a dense opaque, grey dust; a narrow stripe just above the notopleural line is reddish yellow; the pleurae are black, with a darker grey dust, but they are yellowish below the prothoracic stigma; the scutellum is grey on the middle, broadly yellowish at the borders and below; the mesophragma is black, clothed with a dark grey dust, like the pleurae. The short pubescence of the back is pale yellowish like that of the pleurae, which is longer and more sparse; all the bristles are yellowish; the *a. sc.* are as long as the *b. sc.* and are decussate; the *dc.* are placed before the line of the *a. sa.* Halteres whitish. Abdomen shining black, with black hairs and black bristles; the first two segments are dark reddish-brown at the sides, and the first three segments have a narrow reddish hind border; ovipositor depressed, shining black. Legs, including coxae and tarsi, entirely pale yellowish; their hairs are whitish, the spur of the middle tibiae reddish; hind tibiae with a well developed posterior row of bristles. Wings proportionally long and broad; veins pale yellowish at base and on the hyaline dots, blackish on the dark parts. Third and fourth veins distinctly diverging at the end; hind cross-vein perpendicular, a little curved outwardly and slightly longer than its distance from the small one. The pattern is as in *semitra*, with the following differences: the subapical hyaline spot of the submarginal cell is much broader; there are two small hyaline dots in the first posterior cell, the apical one being twice as broad as that placed over the upper end of the hind cross-vein; the second posterior cell

\* These two dots are not shown in Loew's figure, pl. ii, fig. 12; but in the description they are recorded as being sometimes present, it seems therefore that it is a somewhat variable character.



is distinctly more elongate and shows a fourth hyaline spot before its upper apical angle, a little smaller than the three others, which are disposed in a triangle; the basal hyaline spot of the third posterior cell is broadly separated from that of the axillary lobe, which shows two small hyaline dots in the dark space below the sixth vein. Alula whitish hyaline and unspotted. The costal bristle is long and black.

Type ♀, a single specimen from N. Nigeria, Zungeru, 15.ix.1910 (*Dr. J. W. Scott Macfie*).

The character of the long and decussate *a. set.* is common to the present species and *semitra*, Loew, and is in contrast with the other species in which these bristles are rudimentary or even wanting; in *Lamproxyyna* there are likewise only two *set.*, the apical ones being wanting. This character must also be taken with caution in my table of genera; even the character of the *i. or.* can be misleading, as in the present species there are three pairs of these bristles, while the other species have only two pairs.

### **Pliomelaena**, Bezzi, 1918.

#### **Pliomelaena brevifrons**, Bezzi (1918).

A female specimen from Natal, Port Shepstone, v. 1897 (*G. A. K. Marshall*).

### **Euresta**, Loew, 1873.

#### **Euresta amplifrons**, sp. nov. (Pl. xviii, fig. 7).

A robust species of comparatively large size, very near *planifrons*, Loew, but at once distinguishable by the presence of a pair only of scutellar bristles (agreeing in this with the nearly allied *megacephala*, Loew), by the striking abdominal coloration and by the somewhat different wing pattern.

♂. Length of body 7 mm.; breadth of abdomen 2 mm.; length of wing 7 mm.

Head very broad, even a little broader than the thorax, in front view broader than high, in side view about as broad as high; it is entirely yellowish, but clothed with a dense cinereous dust. Occiput concave, with a double blackish spot in the middle, above and on sides of the neck; the rather stout hairs of its lower portion are whitish, like those of the chin. Frons very broad and quite bare, about three times as broad as the eye, and even a little broader than long; it is very flat, being not produced above the eyes, but conspicuously prominent in front above the antennae; it is entirely of a reddish grey colour, the middle band being not distinct from the orbits; the small ocellar dot is blackish; lunula very well developed, broad, semicircular, rather prominent. Cheeks rather broad; face a little shorter than the frons, concave in the middle, rather prominent at the mouth-border, clothed with whitish dust; jowls twice as broad as the cheeks, a little broader than the third antennal joint. Eyes rounded. Antennae inserted a little above the middle of the eyes, very short and much shorter than the face; they are entirely yellowish; first joint with pale yellowish hairs; second joint rather prominent above; third joint shorter than the first two joints together, with the upper terminal angle rather acute; arista yellowish, thickened at base, microscopically pubescent. Proboscis thick, short, yellowish; palpi as long as the proboscis, broad, yellowish, with some bristly, yellowish hairs. All the cephalic bristles



are yellowish, those of the hind border of the head being paler; two *i. or.*, which are more developed than the *s. or.*; *oc.* about as long as the *vt.* Thorax, scutellum, postscutellum and mesophragma entirely black, but clothed with dense cinerous tomentum, which on the back is more clear and shows a little bluish nuance; the short hairs are pale yellowish, like all the macrochaetae, but those of back are darkened at the base and inserted on small blackish dots; *dc.* placed well in front, only a little beneath the line of the *prst.*; *pt.* as strong as the *mpl.*; *st.* even stronger. Scutellum bare, with the *b. set.* only, which are long, divergent, inserted on rather large black spots and placed rather distant from the borders; there is no trace of the *a. set.* Squamulae whitish, with a rather long whitish fringe; halteres pale yellowish, with a little infuscated knob. Abdomen broad and very obtuse at the end; it is reddish yellow above on the first three segments, and quite black on the fourth, which is twice as long as the preceding segment; all the hairs are pale yellowish, like the lateral and apical bristles; venter entirely reddish, even on the last segment; genitalia rounded, blackish brown. Legs rather short and stout; they are entirely reddish and rather bare, with whitish dust; front femora with a row of four stout yellowish bristles beneath on the apical half; hind tibiae without a distinct row. Wings with a distinct costal bristle and with yellowish veins; the distal portions of the 2nd, 3rd and 4th veins are straight and slightly divergent; cross-veins rather close together, their distance being shorter than the length of the straight posterior cross-vein, and the anterior cross-vein being placed only a little before the last fourth of the discoidal cell; lower angle of the anal cell rather acute, but less produced. The pattern is very like that of *planifrons*, but the dark patch is more reduced, not extending basally beyond the stigma, the basal portion of the submarginal cell being thus hyaline, and the point of the bifurcation of the 2nd and 3rd veins being in the shape of a conspicuous black callosity, which is very strikingly developed, while in *planifrons* it is comprised in the dark patch. The hyaline spots at the apex and hind border of the wing are of greater size, the radiating pattern being thus more developed; the discoidal cell is almost completely hyaline on its basal half; the second basal cell is quite hyaline; the dark spot at the lower end of the anal cell is less developed, and there is no dark spot at all below the end of the 6th vein.

Type ♂, a single, rather damaged specimen from Natal, Malvern, v. 1897 (G. A. K. Marshall).

The wing pattern of the present species is not unlike that of some species of the genus *Trypanea*, but is also very like that of *Euaresta conjuncta*, Loew. It is very probable that the present species may be galligenous, like *E. megacephala*, Loew, which in Sicily makes very conspicuous galls on the twigs of the Composite plant, *Inula crithmoides*;\* it is therefore possible that *E. megacephala*, *E. planifrons* and *E. amplifrons* will belong to a natural genus, which is biologically characterized by the faculty of making so-called pleurocecidia on Composite plants, a character rather uncommon in the present group of flower-head flies.

\* T. De Stefani Perez, Marcellia, Avellino, iii, 1904, pp. 122-125; Trotter e Cecconi, Cecidotheca italica, Fasc. xiv, no. 326 (1906); C. Houard, Les Zoocécidies des Plantes d'Europe, etc. ii, 1909, p. 972, no. 5627.

**Ensina**, Rob.-Desv., 1830.**Ensina sororcula**, Wiedemann (1830).

Of this common species there is a male specimen from Natal, Ulundi, 5,000–6,500 ft., ix. 1896 (*G. A. K. Marshall*).

**Ensina gladiatrix**, sp. nov.

Closely allied to the preceding species, but distinguished by the infuscated antennae, the black femora which have only a very narrow yellowish tip, and by the exceedingly long ovipositor of the female.

♀. Length of body 3 mm.; of the basal segment of the ovipositor 1·3 mm., and of the completely exerted ovipositor 3 mm.; of the wing 3 mm.

Head as in *sororcula*, but less depressed and with the frons distinctly shorter; ocellar spot blackish; third antennal joint distinctly infuscated. The thorax seems to be darker and devoid of distinct pattern on the back; the pleurae are more decidedly blackish; there is no trace of *a. scl.* The abdomen seems likewise to be darker above and devoid of distinct pattern; the ovipositor is shining black, depressed, with the basal segment a little longer than the whole abdomen (in *sororcula* it is about a half as long as the abdomen), the second segment shining black, the third segment reddish; if completely exerted, as in the case of the type, the ovipositor is longer than the entire body. In the legs all the femora are entirely black, having only the extreme tip narrowly yellowish, while in *sororcula* they have the apical half yellowish, and the four anterior ones are mainly or even entirely yellow. The wings are proportionally broader and have the same venation; the pattern is very similar, but the stigma is quite black, even at the base; the fuscous reticulation is more developed on the posterior half of the wing, chiefly in the discoidal and the second posterior cells; in the first posterior cell the hyaline spots are disposed in two distinct longitudinal rows, a condition which is never to be observed in *sororcula*, in which they are not very distinct, never ordinate, but are in one row only at least towards the middle of the cell.

Type ♀, a single damaged specimen from Natal, Ulundi, 5,000–6,500 ft., ix. 1896 (*G. A. K. Marshall*).

**Ensina magnipalpis**, sp. nov.

Closely allied to *dubia*, Walker and Loew, but distinguished by the hyaline spot of the stigma, and by the much less numerous hyaline spots of the first basal and discoidal cells.

♂. Length of body 3·8–4 mm.; of wing 4–4·2 mm.

Occiput black, grey-dusted above, yellowish below. Frons flat, not prominent in profile, broad, parallel-sided, about 1·5 times as long as broad; it is of a dark orange-yellow colour, but a narrow longitudinal middle stripe and the orbits are whitish; lunula broad and rounded, yellowish; cheeks narrow, with white shining dust; jowls yellowish, unspotted, as broad as the third antennal joint. Face narrower and shorter than the frons, with broad and very prominent mouth-border. Eyes in profile rounded; antennae inserted a little below their middle; they are entirely yellowish and a little shorter than the face; second joint with yellow

hairs; third joint broad, rounded at tip, about twice the second in length; arista microscopically pubescent. Palpi pale yellowish, with pale hairs; they are very long and broad, flattened, as long as the basal part of the proboscis; the latter is very long, about as long as the head and thorax together; its basal part is produced much beyond the mouth-border, and the apical part is acute and much produced behind the chin. Bristles abraded in the type, but they seem to be whitish on the occipital border and black on the frons; pubescence pale yellowish. Thorax clothed on the back with a dense opaque whitish-grey dust, but with a very broad even longitudinal blackish stripe, which extends laterally to the *dc.*; a smaller lateral blackish stripe on each side above the notopleural line; the back can therefore be described as black with two lateral whitish stripes; the pleurae are entirely greyish and unspotted. The bristles of the back are black; the pubescence is pale yellowish; on the pleurae the *st.* and the *mpl.* are black, while the others are pale yellowish or whitish, like the hairs. Scutellum blackish, greyish at the end and below, with four equally long and strong black bristles, the apical ones diverging. Postscutellum and mesophragma coloured like the pleurae. Squamulae and halteres dirty whitish, the former with a white fringe. Abdomen broad and flat, grey, with two longitudinal rows of blackish spots, which are partly confluent to form two longitudinal stripes; last segment with a broad yellowish hind border; pubescence pale yellowish; apical bristles black; genitalia yellowish; venter yellowish grey. Legs entirely yellowish, the femora more or less greyish on the outer side; hairs and bristles pale yellowish or whitish, only the apical spur of the middle tibiae being black. Wings with a well-developed black costal bristle; costa black on the dark, and yellowish on the hyaline parts; veins black, in part yellowish at base and on the hyaline spots; stigma longer than broad, deep black, with a small circular, sharply defined, whitish hyaline spot before the end. First vein ending before the small cross-vein; 2nd vein straight; 3rd vein bare, straight throughout and parallel with the last portion of the 4th; small cross-vein placed considerably beyond the middle of the discoidal cell; hind cross-vein perpendicular, convex outwardly, distinctly longer than its distance from the anterior one; discoidal cell long; anal cell broader than the second basal cell, with an acute but not produced lower apical angle; 6th vein complete but colourless at the end. The pattern is blackish, more intense on the fore half, paler behind; in general shape it is like that figured by Loew for *dubia* (pl. ii, fig. 20) with the following differences, besides the hyaline spot of the stigma; the hyaline spots in the costal cell are broader; in the base of the submarginal, 1st and 2nd basal and discoidal cells there are only very few, much broader hyaline spots; the 3rd posterior cell has the reticulation closer, being fuscous with about 8 hyaline spots. The axillary lobe is likewise hyaline, with two fuscous rounded spots at the hind border; the anal cell is also hyaline.

Type ♂, and an additional specimen of the same sex from Durban, Umbilo. 28.vi.1914 (*L. Bevis*).

These two species, *dubia* and *magnipalpis*, which agree in palpal and other characters, and have a similar wing pattern with much extended black parts, require the formation of a new genus, if they cannot be placed in the genera *Spathulina* or *Pliomelaena*.



**Ensina siphonina**, Bezzi (1918).

There is an additional specimen of this very distinct species, likewise from British East Africa, Nakuru, i. 1913 (*Dr. B. L. van Someren*).

**Trypanea**, Schrank, 1795.

Of this genus, numerous species of which are tabulated in my previous paper, there are in the new material before me two forms which are both very different in wing pattern from all the other Ethiopian species before known, and are here described as new.

**Trypanea subcompleta**, sp. nov. (Pl. xviii, fig. 8.).

Distinguishable by the four strong scutellar bristles and by the wings, which have the typical star-shaped subapical pattern, but are marked to the base with a faded but well developed reticulation, like that of the American species *abstersa*, Loew, and *reticulata*, Hendel.

♀. Length of body 3.7 mm. ; of ovipositor 0.5 mm. ; of wing 4 mm.

Head of proportionally smaller size and rather narrow in profile, with the purplish eyes higher than broad ; it is greyish, with a dark spot on the middle of the occiput ; frons about as broad as long, not at all prominent in front, with whitish dust in the middle ; lunula rather broad ; face short, not prominent below ; cheeks linear and jowls only a little broader. Antennae inserted at middle of the eyes, only a little shorter than the face, entirely yellow, with the third joint rounded at end ; arista bare. Palpi and proboscis yellowish, the latter short and retracted into the oral cavity. Cephalic bristles dark yellowish, but those of the hind border whitish ; *oc.* long and strong ; three *i. or.*, but the anterior one less than half as long as the others. Thorax blackish on the back, yellowish on the sides, but densely clothed with grey dust, opaque and unicolorous ; the short hairs are pale yellowish, the bristles dark yellowish, those of the back being inserted over small black dots ; *pt.* as strong as the *st.* ; hairs of the hind border of mesopleura rather long. Scutellum like the thorax, but broadly yellowish at the hind border ; *b. sc.* long, diverging, inserted over rather broad black spots ; *a. sc.* a little shorter, decussate, on smaller black spots. Postscutellum and mesophragma entirely grey. Squamulae whitish, halteres pale yellowish. Abdomen like the thorax, with short pale yellowish hairs and yellowish terminal bristles ; the first three segments have a rather broad yellowish hind border ; the 4th and 5th are blacker basally and more yellow apically ; ovipositor depressed, shining black, short and obtuse, a little shorter than the last two abdominal segments together. Venter pale yellowish, with whitish hairs. Legs short and stout, entirely pale yellowish ; front femora above with a complete row of short yellowish bristles, below with an apical row of four very long yellowish bristles ; spur of the middle tibiae blackish ; hind tibiae with a well developed row towards the middle. Wings long and narrow, with a distinct costal bristle and pale yellowish veins, which are infuscated on the darker parts of the pattern ; first vein ending much before the small cross-vein ; 2nd, 3rd and 4th veins straight in their terminal portions and equally and gradually divergent ; cross-veins perpendicular and parallel, the hind one being longer than its distance from the anterior one ; lower angle of the anal cell acute but less produced ; 6th



vein prolonged to the hind border. The star-shaped apical patch is blackish brown; it encloses a triangular indentation into the marginal cell, two hyaline spots near the border at end of the submarginal cell, one just below the end of the 2nd vein and the other broader and subquadrate before the end of the 3rd vein. The first posterior cell has two hyaline spots at base, the first as long as the breadth of the cell itself and in contact with the small cross-vein, the second rounded, half as long, and in contact with the 4th longitudinal vein; the cell has at the end the three usual spots, which form the two usual radiating branches; two other fuscous parallel rays are in the second posterior cell, and another less distinct ray on the hind cross-vein. The fuscous rays at the apex and hind border are therefore five in number. The basal portion of the wing shows a pale but complete reticulation, formed by rounded hyaline spots of rather large size; of these spots there is a row only in the base of the submarginal and first basal cells; the discoidal cell has a row in the basal, and two rows in the apical half; the third posterior cell has ten broader spots disposed in two rows, and along the hind border three more spots; axillary cell with six spots in two rows. The base of the second posterior cell has three spots, two larger and one small, between the ray of the hind cross-vein and the middle ray. The short stigma is quite colourless, with only a black dot near the costa at base of the costal bristle; it is not united with the subapical patch; the oblique ray departing from it and extending to the small cross-vein is very faint and belongs to the pale reticulation.

Type ♀, a single specimen from British East Africa, Nairobi, 27.iv.1911 (*T. J. Anderson*).

From *T. abstersa* (which I have in my collection from California, New Mexico and Colorado) the present species differs in the closer reticulation of the wings, in the wholly colourless stigma, and in the want of the hyaline spot in the marginal cell, just above the end of the second longitudinal vein (not to be confounded with the hyaline spot in the submarginal cell just below the end of the same vein). From *T. reticulata* it differs in the subapical brown patch being much more extended and more typically shaped.

### ***Trypanea peregrina*, Adams (1905).**

Having had occasion to see the type of this species in the Entomological Museum of the University of Kansas, Lawrence, I must recognize that it is the same as my *T. urophora* of the preceding paper, as already suspected. The figure 11 on pl. i, is too dark, the ray extending from the stigma to the small cross-vein being really much paler and interrupted. The form of the ovipositor is the same, even though it is depressed in the type of *peregrina*.

### ***Trypanea hemimelaena*, sp. nov. (Pl. xviii, fig. 9).**

A pretty species recalling *T. guimari*, Becker, from the Canary Islands, and likewise with the apical half of the wing only occupied by a not typically star-shaped pattern, which shows however more numerous hyaline spots.

♂. Length of body 3.2 mm.; of wing 3.2 mm.

Head entirely pale yellowish, clothed with whitish dust, and only narrowly blackened towards the middle of the occiput, above the neck; it is rather large,

being in front view broader than high, and in side view higher than broad; eyes greenish, unicolorous, higher than broad. Frons flat, a little prominent in front above the base of the antennae, as long as the face, with a broad bare yellow middle stripe, and with a whitish-grey ocellar triangle and lateral orbits; lunula broad, semicircular, whitish grey. Face flat, with shallow antennal grooves and the upper mouth-border not prominent, cheeks linear; jowls only about twice as broad as the cheeks, unspotted. Antennae inserted above the middle of the eyes, much shorter than the face; they are pale yellowish; third joint pubescent, with the upper terminal angle a little infuscated and not acute; arista microscopically pubescent, yellowish, thickened at base. Palpi and proboscis yellowish, the latter thick and short, retracted into the broad oral cavity. All the cephalic bristles are pale yellowish, those of the hind border whitish; *oc.* long and strong; two *i. or.*; genal bristle distinct, but short and whitish; the rather short hairs of the lower part of the occiput and of the chin are whitish. Thorax black in ground-colour but clothed with a dense grey dust, which on the back is more clear and a little yellowish, and darker on the pleurae; there is no distinct pattern on the back, except an ill-defined dark stripe below the notopleural line; all the hairs and bristles are whitish, the latter being inserted over very small but striking black dots; *dc.* placed near the suture; *pt.*, *mpl.* and *st.* well developed, but intermingled with rather long and stout hairs. Scutellum coloured like the back of mesonotum and likewise pubescent; the two basal bristles are inserted over proportionally broad dark spots; the apical bristles are medium-sized and decussate at the end. Postscutellum and mesophragma clothed with a dense grey (not yellowish) dust. Squamulae and halteres pale yellowish. Abdomen elongate and rather attenuate at the end; it is densely tomentose like the back of the mesonotum (in *guinari* it is less tomentose, the black ground-colour being visible) and clothed with rather long pale yellowish hairs; hind border of the first two segments distinctly yellowish; venter blackish, with short scattered whitish hairs; genitalia black. Legs rather short and stout, entirely reddish, the front coxae grey-dusted; they are clothed with a short whitish pubescence; front femora with five stout yellowish bristles beneath; hind tibiae with no distinct row. Wings proportionally short and broad, with a distinct costal bristle and pale yellowish veins, which are blackened on the apical half; 3rd and 4th veins straight and a little divergent at the end, while the 2nd is more strongly divergent from the 3rd; cross-veins straight and parallel, the small one placed near the last fourth of the discoidal cell, the posterior one longer than its distance from the small one; lower corner of the anal cell forming a wide angle; 6th vein prolonged to the hind border, even if very faint. The stigma is very short and pale yellowish, with a small black dot near the base of the costal bristle; the first vein ends much before the small cross-vein (in *guinari* it ends below or only a little before it). The basal half of the wing is entirely whitish hyaline and quite unspotted. The apical part is occupied by a dark brown patch, which is less dark towards the hind border, and has a yellowish patch on the small cross-vein into the end of the first basal cell, prolonged above into the submarginal cell towards the stigma. In the brown patch there are the following hyaline spots; two spots close together in the marginal cell just beyond the stigma, the first very broad

and subquadrate, the second much narrower and subtriangular; in the submarginal cell there are three rounded spots, one in the middle just above the upper end of the small cross-vein and at the inner end of the upper part of the yellowish patch, the other at the fore border just below the tip of the 2nd vein, the third of greater size and subtriangular just before the lower apical angle. The first posterior cell has a rounded spot near the base, half as broad as the distance between the 3rd and 4th veins and in contact with this last vein before the upper end of the hind cross-vein; two other spots before the end, one over the other, that in contact with the 3rd vein being smaller than that in contact with the 4th; and one apical, extending from the 3rd to the 4th vein, and thus forming the normal apical dark fork of the *Trypanea*-pattern, though a little shorter than usual. Discoidal cell with four about equally small, rounded spots, disposed as a square. Second posterior cell with three larger rounded spots along the hind border, of an indentation-like shape, and one of equal size near its upper inner angle. Third posterior cell with a single rounded spot of greater size before its lower apical angle and in contact with the hind border of the wing.

Type ♂, a single specimen from the Gold Coast, Aburi, 1912-13 (*W. H. Patterson*).

Owing to the great affinity of the present species with *T. guimari*, which shows a very remarkable sexual dimorphism, it is possible that the unknown female has a somewhat different wing pattern. These two species, like *T. peregrina*, belong evidently to the *gnaphalii-mamulae* group.

#### V. Subfam. SCHISTOPTERINAE.

This peculiar subfamily is represented in the new material before me by two remarkable forms, one of which requires the formation of a new genus, while the other, being closely allied to *Rhabdochaeta spinosa*, Lamb (1914), from the Seychelles, may be provisionally placed in the Oriental genus *Rhabdochaeta*, de Meij.

An important character of the subfamily is that the *s. or.* are placed on a line converging towards the centre of the frons, being thus not in the same line with the *i. or.*

#### *Perirhithrum*, gen. nov.

This new genus is more closely allied to the Oriental *Rhabdochaeta* than to the Ethiopian genera *Schistopterum* or *Rhochmopterum*, but differs from all the known genera of the subfamily in having the first and third longitudinal veins bristly above, in having a produced lower angle in the anal cell and in having a very oblique hind cross-vein.

From *Rhabdochaeta* the new genus differs in the want of the middle pair of bristles on the frontal stripe. These bristles are likewise wanting in *Schistopterum* and are not mentioned for *Rhochmopterum*; they are recorded for the type species of the genus *Rhabdochaeta*, as well as for the species *spinosa*, Lamb, and are present also in my species *bakeri* from the Philippines. This pair of bristles seems to correspond to the crossed frontal pair of the ANTHOMYIIDAE: but in *Rhabdochaeta* they are not crossed. It is interesting to note the presence of a similar pair of bristles in the male of *Euribia perpallida*, Bezzi (as pointed out by me in vol. ix, p. 35, note), the wing-pattern of which rather recalls that of the SCHISTOPTERINAE.



Body robust, of comparatively large size, with strong bristles of different coloration, but not of different kind. Head in front view broader than high, in side view rather narrow. Eyes bare, of large size, distinctly higher than broad. Occiput rather flat and not swollen below. Frons about as long as broad, with nearly parallel sides, not at all prominent in front; middle band devoid of central bristles; lunula rather small and deeply excavated. Face shorter than the frons, concave in the middle and with a very prominent border at the upper mouth-edge and at the sides of the mouth; cheeks linear; jowls very narrow. Antennae inserted at middle of the eyes and as long as the face; first joint very short; second joint prominent above and there clothed with short obtuse stout bristles; 3rd joint about as long as the first two joints together, of a rectangular shape, with the upper terminal angle acute but not very prominent; arista longer than the antennae, with rather long pubescence. Mouth-opening broadened anteriorly; palpi long, flattened, bristly, prominent and of the usual shape for the subfamily; proboscis short, with short and broad terminal flaps. Occipital row formed by stout obtuse whitish bristles; inner *vt.* very long; *oc.* long and strong, widely distant from each other at the base; two *s. or.*, not in the same line with the three *i. or.*, but converging in front and thus the anterior pair about in front of the *oc.*; middle frontal band bare; genal bristle strong; lower portion of the occiput with scattered stout hairs. Thorax about as long as broad, moderately convex above, with sparse scattered pubescence, even on the pleurae. Chaetotaxy complete, but with no distinct *scp.*; *dc.* placed near the suture and a little before the line of the *a. sa.*; one *mpl.*; *pt.* a little weaker than the *st.* Scutellum broadly triangular, gently convex above, clothed with sparse hairs; *b. scf.* long and diverging; *a. scf.* well developed, but broken in the type. Abdomen elongate, narrower than the thorax, nearly bare above and on the sides, with some rather stout bristles at the end; male genitalia globose and rather prominent downwards. Legs rather slender, the femora not incrassated; front femora with a complete row of strong bristles below; middle tibiae with a single spur; hind tibiae with no distinct row on the outer side. Wings rounded and very broad; costal bristle well developed, with a second much smaller one before it; there is also a group of 4-5 short bristly hairs at the costa near the humeral cross-vein and its incision. The incision at the end of the auxiliary vein is present, but much shorter and less prominent than typically. Auxiliary vein well developed, but ending at a straight angle and there evanescent; first vein ending about at middle of the fore border and distant from the costa (the costal and subcostal cells being thus very broad), and suddenly bent forwards at tip; it is clothed with bristles, which on its terminal part are very long. Stigma distinct, about as broad as long. Second vein long, straight, a little bent forwards at the apex, ending nearer to the end of the 3rd than to that of the first vein. Third vein quite straight, clothed with short bristles to the middle of its last portion; the submarginal cell is greatly widened at the end, because the 2nd vein is strongly divergent from the 3rd, which is parallel with the longitudinal axis of the wing. Fourth vein likewise straight and in its last portion quite parallel with the last portion of the third. Small cross-vein normally developed, straight, perpendicular, about as long as its distance from the upper end of the hind cross-vein; it is placed near the terminal third of the upper border



of the discoidal cell, but near the middle of the lower border of the same cell. Cubital fold well developed and forked outwardly, evenly chitinated. Hind cross-vein broadly S-shaped, but placed very obliquely so that its upper end is near the middle of the wing, while its lower end is very near the end of the fifth longitudinal vein; the lower external angle of the discoidal cell is therefore very acute and much produced outwardly. Anal cell broad, with its lower outer angle acute and produced longer than the 2nd basal cell; sixth vein prolonged to the hind border of the wing. Axillary lobe broad and rounded, with a distinct long axillary vein; alula well developed, rounded. The wing pattern is a very characteristic one, consisting of a broad, light brown patch, occupying the middle and extending over the whole hind portion of the wing, except the apex; this patch shows black spots, shining "bullae" and subhyaline spots near the hind border; from this patch depart numerous long rays, which extend to the costa along the entire fore border and the entire apex.

Type: the following new species.

**Perirhithrum marshalli**, sp. nov. (Pl. xviii, fig. 10).

A strange and beautiful insect of comparatively large size, strikingly distinguished by the very peculiar wings.

♂. Length of body 5.5 mm.; of wing 5.5 mm.; breadth of wing 3 mm.

Head yellowish, darkened towards the middle of the occiput. Frons with a dark ocellar spot and with a transverse dark band in front before the lunula. Antennae reddish yellow, with the third joint blackened along its upper border; arista whitish, cheeks white, with a small deep black, rounded spot above on each side, near the roots of the antennae; jowls yellowish, with a reddish spot on each side in front; face yellowish, darkened towards the middle. Eyes reddish brown and apparently unicolorous. Palpi whitish at base, reddish yellow on the apical half, and clothed there with short black bristles; proboscis reddish yellow. The *ocp.*, the outer *vt.* and the *pvt.* are whitish; the long inner *vt.* are black, while the *oc.* are pale yellowish; the long and strong *s. or.* are black with a brownish end and are inserted over distinct, black, slightly prominent tubercles, like the first (or inner) of the *i. or.*, which is likewise black with a brownish tip; the two apical pairs of the *i. or.* are on the contrary shorter and whitish. The genal bristle is black, while the rather long, bristly hairs near it on the chin, and those on the lower part of the occiput, are whitish. Thorax on the back black in ground-colour, but covered with dark grey dust; the suture is broadly interrupted in the middle, with whitish dust on the sides and has inwardly a brownish transverse band, which is interrupted towards the middle; the points of insertion of the bristles are darker and spot-like, and there are in the centre two dark brownish rounded spots, one on each side, interiorly and posteriorly of the anterior *dc.*; the back is denuded in the type, but in front of the scutellum it shows rather long and scattered whitish hairs. The pleurae are yellowish near the sutures and towards the breast, but are darkened towards the centre of the sclerites; they are clothed with a whitish-grey dust. All the macrochaetae are pale yellowish, but those of the back are distinctly black at base, though less so in the case of the *mpl.* and *st.*, while the *pt.* is entirely whitish. Scutellum coloured like the back of the mesonotum, but less obviously

yellowish on the sides and below; the *b. sc.* are very long, pale yellowish, with a black base, and are inserted on a small black dot; the *a. sc.* are wanting in the type. Postscutellum and mesophragma blackish, grey-dusted. Halteres with yellowish stalk and blackish knob. Abdomen reddish, with pale grey dust; each segment bears on each side a very broad, brown spot, which is rectangular in shape on the three basal segments, while it is subquadrate on the fourth; it could be said that each segment is brown, with a narrow whitish hind border and a whitish middle line; each segment bears moreover on the sides, in the whitish portion, a smaller dark spot, and the 4th segment is broadly yellow at the hind border. The entire abdomen seems to be bare, with only a few scattered short black hairs on the sides of the segments, chiefly of the last one, which bears moreover 8-10 not long but strong, black bristles at the hind border and on the sides. Genitalia reddish yellow; venter entirely reddish, with whitish dust and sparse whitish hairs. Legs entirely pale yellowish, even to the end of the tarsi, but each femur is adorned below with two rounded dark spots, one near the base, the other towards the middle; the hairs and bristles of the front femora are pale yellowish, while the posterior femora have blackish pubescence and some dark bristles at the end above; middle tibiae with a dark spur. The wing veins are yellow but darkened on the darker parts of the pattern, and more strikingly on the costa, which is alternatively black and yellow. The short costal bristles near the humeral cross-vein are yellowish, while the two costal bristles at the stigma are black, like the bristles on the 1st and 3rd longitudinal veins. The pattern is brownish, more blackish at the end of the rays of the fore border and on several of the central spots; the membrane is iridescent, quite hyaline on the fore border and at the apex, while the hyaline spots of the hind border are more whitish. The radiating part shows the following dark rays, which become progressively longer from the base to the apex of the wing; one at the extreme base of the first costal cell; one like a narrow border of the humeral cross-vein; two in the second costal cell, one broader near the base, and one narrower but darker beyond the middle; one narrow and greyish along the diffuse terminal part of the auxiliary vein; three blackish, close together and very marked on the stigma, the first and broadest of all at the base, the second in the middle, the third and narrowest along the terminal part of the first vein. In contact with the last of these rays there is a broader triangular greyish ray departing from the fuscous base of the marginal cell and showing some small, subhyaline, whitish streaks on its base. This ray is followed by two other parallel rays at equal distances in the marginal cell itself; these two rays are narrower and bent a little outwardly, and have their central stripes whitish hyaline. There are subsequently two dark rays in the submarginal cell, narrow and full, one ending at the end of the second vein, the other ending at middle of the distance between the tips of the 2nd and 3rd veins; the 1st posterior cell has likewise two narrow rays which follow exactly the two external branches of the cubital fork, ending at the tips of the 3rd and 4th veins; the 2nd posterior cell has the last three rays, which are less sharply defined, the last one being even hardly distinguishable from the dark patch; they are more irregular and sinuous and enclose two small, hyaline spots and a hyaline streak at the base. On the disc of

the wing there are: (1) the blackish patches, two of which more striking and more defined are of subquadrate shape and placed one in the submarginal cell before the small cross-vein, and the other near the base of the first posterior cell, just above the upper end of the hind cross-vein; (2) the shining "bullae," the more distinct of them being placed around the small cross-vein at unequal distances to form a kind of circle: one in the first basal, one in the submarginal just above the small cross-vein, two in the first posterior above and in front of the black spot, and one in the discoidal cell, at some distance below the above-named black spot. There are moreover some other "bullae," one at the extreme base of the submarginal cell, and one at the extreme base of the discoidal cell extending into the end of the 2nd basal cell. The 3rd posterior cell and the axillary lobe are entirely and evenly infuscated and show some hyaline spots forming a kind of reticulation; 9 of these spots are placed into the axillary cell, 4 above and 5 below the axillary vein, and 7-8 are placed in the 3rd posterior cell, those near the apex being more stripe-like. The hyaline parts of the stigma are colourless, like the corresponding ones of the 2nd costal or marginal cells. The basal and anal cells are infuscated to the base, only the extreme base of wing and the alula being greyish hyaline.

Type ♂, a single partly damaged specimen from Natal, Port Shepstone, v. 1897: another of the interesting discoveries of *Dr. G. A. K. Marshall*, in whose honour the species is named.

### ***Rhabdochaeta neavei*, sp. nov.**

About the same as *R. spinosa*, Lamb, from the Seychelles, but seeming to differ in the wing pattern, which is yellowish brown, not black, and shows therefore a very remarkable deep black spot at the base of the first posterior cell, just beyond the small cross-vein.

♀. Length of body 2.2 mm.; of ovipositor 0.8 mm.; of wing 3 mm.

Head yellowish, with the occiput darkened towards the middle; frons yellow on the apical half, with whitish orbits and a blackish ocellar dot; cheeks whitish, with a small, rounded, rather prominent, deep black dot above, between the root of the antenna and the eye; face whitish, with a brown transverse band above the mouth-border; jowls very narrow and unspotted. Antennae pale yellowish at base, with the 3rd joint more yellow, very attenuated and very acute at the end; arista whitish, shortly pubescent. Palpi and proboscis dirty yellowish. Middle frontal stripe bare, but with a pair of white bristles in the middle. Cephalic bristles pale yellowish, the *or.* and the inner *vt.* darkish at base; those of the hind border are whitish; two *s. or.* and three *i. or.*, counting that placed far in front, just above the black dot of the cheeks; the stout short hairs of the lower part of the occiput are whitish. Thorax black in ground-colour, but densely clothed with grey dust, which is darker on the pleurae; humeri and notopleural region yellowish; on the back there are distinct black spots on the points of insertion of the macrochaetae, those of the *prsc.* being the most developed; the short hairs are pale yellowish; the dorsal macrochaetae are distinctly blackened at the extreme base, but are elsewhere yellowish; the pleural macrochaetae are



entirely pale. Scutellum like the back of the mesonotum, but broadly yellowish at the sides and behind; the *b. sc.* are blackish at base and inserted over black spots; the *a. sc.* are much smaller, decussate at the end, not darkened at the base and not inserted on black spots. Postscutellum and mesophragma black but clothed with grey dust, which is darker on the former. Squamulae and halteres whitish. The abdomen seems to be differently coloured from that of *spinosa*, being entirely reddish, with the base of the first two segments narrowly blackish; hairs and bristles pale yellowish; ovipositor broad, flattened, with the basal segment shining reddish with black end. Legs pale yellowish, with dark pubescence and whitish bristles; front femora beneath before the end with a blackish spot, forming an incomplete ring, and there with blackish bristles; the four posterior femora have this spot more developed, and have moreover a similar but more elongate spot near the base; all the tibiae have a narrow black ring near the base, less developed on the front pair; hind tibiae with a short but distinct posterior row of bristles. The wings are shaped as in Lamb's figure 13, p. 321; they have the same venation, with a deeply sinuous fourth longitudinal vein and a nearly straight hind cross-vein; in the Oriental species *pulchella* and *venusta* the fourth vein is almost straight, but the hind cross-vein is likewise about straight; in *bakeri* the fourth vein is straight, while the hind cross-vein is broadly S-shaped and oblique. The veins are bare, as stated by Lamb; but on the third vein I can perceive some scattered, almost microscopic, black bristles. The general shape of the pattern is the same; it is however not black, but yellowish brown; the shining "bullae" are of the same number and have the same disposition; but the wing pattern being more clear, the black spot at the base of the first posterior cell is very striking; it is placed below the basal "bulla" of the same cell, and bears at base a small rounded whitish-hyaline dot, corresponding to that figured by Lamb at the inner basal angle of the first posterior cell. Other differences are: (1) the marginal cell has no hyaline spots in the fuscous part at the base of the radiating streaks; (2) the hyaline dots in the submarginal, first basal and first posterior cells are less numerous and much smaller. It must be remarked that in the present species, as well as in *spinosa*, the costal nick, even if distinct, is much less developed than in *pulchella* and *bakeri*; de Meijere's figure of *venusta* shows it however not developed.

Type ♀, a single specimen from Nyasaland, S.W. of Lake Chilwa, 13.i.1914, collected by *S. A. Neave*, in whose honour the species is named.

Two species of *Euribia*, *perpallida* and *discipulchra*,\* both likewise from Nyasaland, show a very remarkable affinity with the above-described species of *Rhabdochaeta*, and are perhaps allied; but they have different wing pattern, unicolorous legs, etc.

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\* Bull. Ent. Res. ix, 1918, pp. 35, 36.







## EXPLANATION OF PLATE XVII.

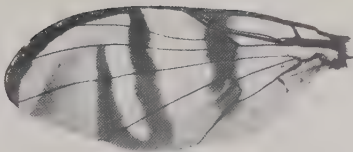
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### Wings of Trypetidae.

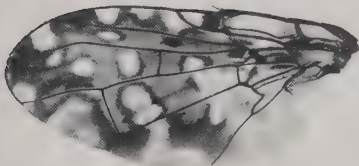
- Fig. 1. *Sosiopsila trisetosa*, Bezzi, sp. nov.  
2. *Conradtina acrodiauges*, Speiser.  
3. *Leucotaeniella guttipennis*, Bezzi, sp. nov.  
4. *Celidodacus obnubilus*, Karsch.  
5. *Bistrispinaria fortis*, Speiser.  
6. *Clinotaenia anastrephina*, Bezzi, sp. nov.  
7. *Hoplolopha cristata*, Bezzi, sp. nov.  
8. *Rhacochlaena pulchella*, Bezzi, sp. nov.  
9. *Taomyia marshalli*, Bezzi, sp. nov.  
10. *Notomma bioculatum*, Bezzi, sp. nov.
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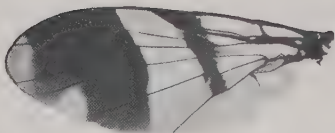
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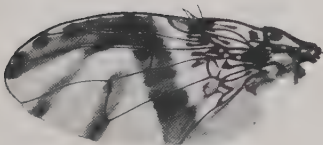
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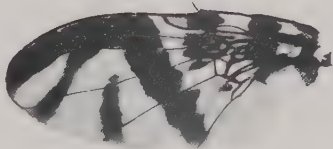
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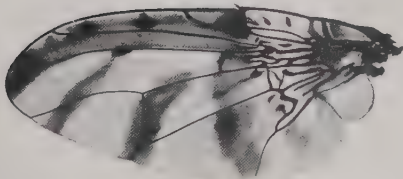
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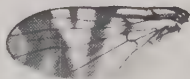
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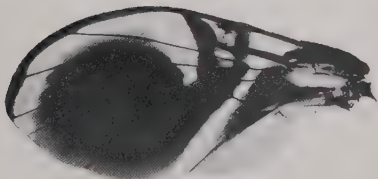
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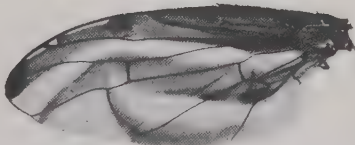
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AFRICAN FRUIT FLIES.





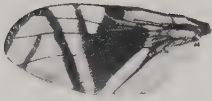


## EXPLANATION OF PLATE XVIII.

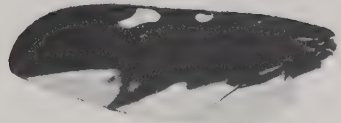
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### Wings of Trypetidae.

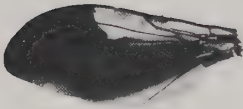
- Fig. 1. *Acidia fossataeformis*, Bezzi, sp. nov.  
2. *Ocneros bigemmatu*s, Bezzi, sp. nov.  
3. *Allotrypes brevicornis*, Bezzi, sp. nov.  
4. *Aciura perpicillaris*, Bezzi, sp. nov.  
5. *Aciura oborinia*, Walker.  
6. *Spheniscomyia neavei*, Bezzi, sp. nov.  
7. *Euaresta amplifrons*, Bezzi, sp. nov.  
8. *Trypanea subcompleta*, Bezzi, sp. nov.  
9. *Trypanea hemimelaena*, Bezzi, sp. nov.  
10. *Perirhithrum marshalli*, Bezzi, sp. nov.
-



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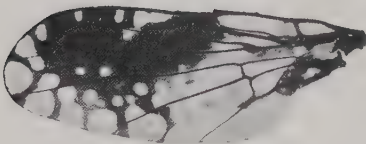
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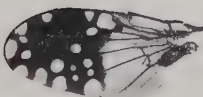
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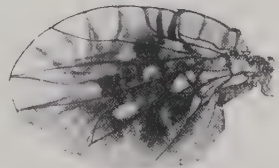
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AFRICAN FRUIT FLIES.





## SOME INJURIOUS SOUTH AFRICAN WEEVILS.

BY GUY A. K. MARSHALL, D.Sc.

(PLATE XIX.)

The following undescribed species of CURCULIONIDAE were all forwarded to the Imperial Bureau of Entomology from the Division of Entomology, Pretoria, with the information that they were attacking various cultivated plants.

## Subfamily BRACHYDERINAE.

**Prototsrophus\* planatus**, sp. nov. (Plate xix, fig. 4).

♂. Unusually flattened dorso-ventrally. Colour black, with uniform and fairly dense brownish-grey scaling above and grey scaling beneath.

*Head* separated from the rostrum by a slightly curved furrow which does not nearly meet the lateral margins; the forehead flat, with a deep and complete central furrow, and the sculpturing hidden by the scaling and the broad subrecumbent brown setae; the eyes strongly convex, moderately produced backwards, deepest behind the middle, and the hind edge of the orbit not projecting. *Rostrum* a little shorter than its basal width, strongly narrowed from base to apex, the sides almost straight; the upper surface with a rather deep median impression containing a complete narrow central carina, and a very shallow longitudinal impression near each lateral margin; the mandibles densely squamose. *Antennae* with joint 1 of the funicle much longer and thicker than 2, which is nearly twice as long as 3, and all the joints much longer than broad. *Prothorax* twice as broad as long, the sides strongly rounded, broadest well behind the middle, the basal margin arcuate, the apex much narrower than the base and broadly sinuate; the upper surface moderately convex transversely, but flat longitudinally, set with large shallow separated setigerous punctures, which are normally hidden by the scaling, and with a narrow smooth central line running from the base for three-fourths the length; the setae broad, flattened and recumbent. *Elytra* oblong-ovate, obtusely pointed behind, the basal margin jointly sinuate, with the angles not produced; the striae very shallow, the first three strongly curved outwards at the base, the very shallow punctures normally quite hidden by the scaling; the intervals broad, flat and minutely punctulate, set with irregular recumbent scale-like setae; the scales very short ovate or almost circular, smaller than those on the prothorax and closely contiguous. *Legs* stout, densely clothed with grey scales and numerous oblique scale-like setae; the front tibiae strongly incurved at the apex, somewhat flattened internally and there with a row of 4 or 5 spine-like bristles, the apical comb with 6 or 7 very short teeth; the hind tibiae slightly convex externally, internally flattened and with 3 stout teeth near the apex, the corbels squamose; joint 2 of the front tarsi a little longer than its apical width. *Sternum* with the mesepisterna broadly separated from the base of the elytra.

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\* Ann. Mag. Nat. Hist. (9) i, 1919, p. 14.

Length, 5.5–7 mm. ; breadth, 3–4 mm.

TRANSVAAL: East Rand, 30.i.1919.

Described from three specimens.

In its colouring and general sculpture this species most closely resembles *P. (Strophosomus) gravis*, Gyl., but is readily distinguished from it by its remarkably flattened form and almost oblong elytra.

Recorded as injuring the foliage of young orange trees.

**Protothrophus noxius**, sp. nov. (Plate xix, fig. 1).

♀. Colour black, with dense sandy brown scaling above, variegated with some paler and darker markings, and uniform sandy grey beneath; the prothorax with usually a broad lanceolate darker median stripe and a broader pale lateral stripe; the scaling on the elytra brown, with a broad whitish stripe on interval 6 and usually with a macular stripe of alternating dark brown and pale spots along striae 1, 2 and 5.

*Head* separated from the rostrum by an abbreviated and deeply curved stria, the forehead smooth, with a single deep furrow, and densely clothed with overlapping scales and raised scale-like setae; the eyes moderately convex, deepest about the middle, projecting strongly backwards, but the hind edge of the orbit not produced. *Rostrum* a little more than half as long as the basal width (5:9), very strongly narrowed from base to apex, with the sides slightly sinuate; the upper surface quite flat, with only a very shallow indistinct impression in the middle of the apical half; the mandibles squamose, the mandibular appendages gently curved, simple and tusk-like, flattened ventrally and with the surface partly striate longitudinally. *Antennae* with joint 1 of the funicle about as long as the next three, joint 2 about as long as broad, the remainder broader than long. *Prothorax* twice as broad as long, a little broader than the base of the elytra, the basal margin strongly arcuate, the apical margin somewhat narrower and trisinate, the lateral margins subdenticulate and gently rounded, broadest at the middle; the upper surface strongly convex transversely and flat longitudinally, quite smooth and evenly covered with dense scaling, without any trace of a furrow or carina. *Elytra* broadly ovate, widest behind the middle, very broadly rounded behind, the basal margin strongly sinuate, fitting closely to the prothorax, with the external angles slightly projecting; the extremely shallow striae bear rows of punctures that are visible through the scaling, each containing a minute scale; the intervals broad, almost flat, densely covered with almost circular overlapping scales equal to those on the prothorax and each with a row of short recumbent scale-like setae. *Legs* with the front tibiae moderately incurved at the apex, the inner surface with two or three spine-like setae, the apical margin with a row of five or six stout teeth and an additional one on the outer edge; the hind tibiae with two internal spines near the apex, and the corbels densely scaly; joint 2 of the front tarsi much broader than long. *Sternum* with the mesepisterna separated from the elytra.

Length, 3.25–3.6; breadth, 2–2.2 mm.

ORANGE FREE STATE: Clocolan, 20.vii.1915.

Described from three specimens.

Somewhat like a small *P. funestus*, Pér., but in the latter species the prothorax is distinctly broader in relation to the elytra, its posterior angles are sharp right angles and its anterior ones acute; and the elytra fit less closely to the prothorax.

Found feeding on young wheat.

**Protostrophus instabilis**, sp. nov. (Plate xix, fig. 2).

♂ ♀. Colouring variable; piceous, with dense grey scaling; the prothorax with a more brownish median lyre-shaped patch and two indistinct sinuous stripes on each side of the same colour; the elytra with interval 1 always fawn coloured, elsewhere irregularly mottled with dark brown; usually pale spots stand out rather conspicuously on intervals 3 and 5 behind the middle, and sometimes these are linked up to form a continuous oblique pale band; occasionally the elytra are distinctly striped, intervals 3 and 5 being almost entirely dark brown and the rest (except 1) light grey.

*Head* separated from the rostrum by a slightly sinuate stria that reaches the sides, the forehead almost flat, with a single deep furrow and the sculpturing quite hidden by the scaling, and set with obliquely raised flattened setae; the eyes not very prominent, deepest far behind the middle, the posterior edge of the orbit not projecting. *Rostrum* distinctly broader than long, not very strongly narrowed in front, the sides almost straight and with a slight rounded projection above the apex of the scrobe; the upper surface nearly flat, with a shallow median depression in the apical half, and without any distinct carina; the mandibles not squamose. *Antennae* with joint 1 of the funicle much longer and broader than 2, which is as long as 3 and 4 together, 3-7 transverse, 7 as broad as 1. *Prothorax* about twice as broad as long, broadest at the middle, the sides very strongly (subangulately) rounded, the base slightly arcuate, with the basal angles rounded off, no broader than the apex, which is truncate; the upper surface flat longitudinally and smooth, the sculpturing completely hidden by scaling, except for a shallow median stria, which is abbreviated at both ends. *Elytra* oblong-ovate, the sides obtusely angulated near the base and from there subparallel to beyond the middle, broadly rounded behind, with the base very shallowly sinuate and the basal angles not projecting; the shallow striae contain separated punctures that are clearly visible through the scaling; the intervals broad, almost flat, finely coriaceous, and densely clothed with almost circular overlapping fluted scales (of the same size as those on the prothorax) and each with a single row of raised brownish scale-like setae, which become longer and more erect behind, a few across the top of the declivity being white. *Legs* densely clothed with scales and sub-recumbent scale-like setae; the front tibiae only slightly incurved at the apex, with two spines on the inner face, and an apical row of three small and three stout teeth and two stout ones on the outer edge; the hind tibiae with three spines internally on the apical half and the corbels densely squamose. *Sternum* with the mesepisterna narrowly separated from the elytra.

*Length*, 3-3.5 mm.; *breadth*, 1.75-2 mm.

TRANSVAAL: Nelspruit, 25.ix.1918.

Described from ten specimens.



This species differs from typical forms of the genus in the following points :— the obliteration of the longitudinal impressions on the lower surface of the rostrum ; the extension of the transverse cephalic stria to the lateral margin ; the narrowness of the basal margin of the prothorax ; and the humeral angulation on the elytra. In all these characters it agrees with *Bradybamon*, Mshl. (Ann. Mag. Nat. Hist. (9) i, 1919, p. 9), from which however it differs abundantly in the structure of the epistome, mentum, eyes, venter, etc.

Recorded as injuring the foliage of young orange trees.

***Eremnus horticola*, sp. nov. (Plate xix, fig. 3).**

♂ ♀. Colour black, densely clothed with sandy grey scaling, irregularly mottled above with brown markings.

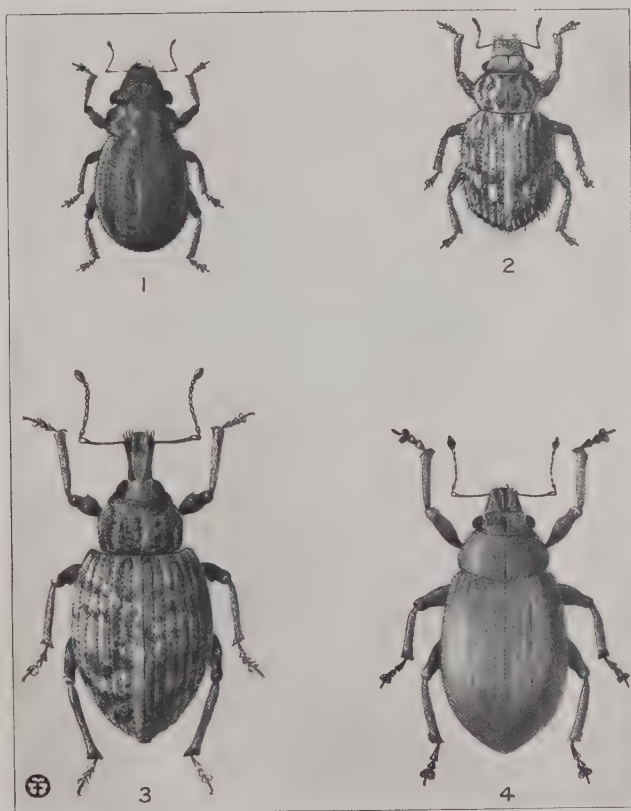
*Head* with the rugose sculpturing entirely concealed by the scaling ; the forehead flattened, as broad as the base of the rostrum and with a central fovea. *Rostrum* parallel-sided at the base, then gradually widening to the apex, very deeply compressed behind the scrobes, leaving a raised dorsal area with perpendicular sides, which rapidly narrows from the apex almost to a point at the base ; the dorsal area broadly impressed in the apical half and rugosely punctate, the punctures hidden by almost circular large overlapping fluted scales. *Antennae* with the scape gently curved just below the middle and slightly exceeding the hind margin of the eye ; the funicle with joint 2 half as long again as 1, joints 3–6 gradually diminishing, and 7 as long as but broader than 4 ; the club as long as the three preceding joints. *Prothorax* half as broad again as the median length, the sides rounded, broadest before the middle, deeply constricted and broadly sulcate transversely near the apex ; the basal margin slightly arcuate, the apex broadly sinuate dorsally, the postocular lobes broad but rather short ; the upper surface uneven, the central area granulate-punctate, with four foveae forming the corners of a transverse parallelogram and with a shallow central furrow towards the base ; on each side of the central area a very broad and deep furrow, bounded externally by a sharp carina, beyond which the surface is rugosely granulate ; all the granules covered with scaling. *Elytra* rather broadly ovate in ♀, narrower in ♂, broadest about the middle and obtusely pointed behind ; the dorsal outline only slightly curved, the posterior declivity very steep and curving inwards near the apex, which is hidden from above (especially in the ♀) ; the basal margin gently sinuate and vertically truncate, almost marginate for a short distance on each side of the suture ; the striae shallow and with separated shallow punctures, which are partly hidden by the scaling ; the intervals moderately convex, the alternate ones higher at the base, and the suture obtusely elevated on the declivity, less so in ♂ than in ♀ ; the scales much smaller than those on the prothorax, almost circular, fluted and slightly overlapping, the short recumbent scale-like setae irregularly disposed. *Legs* with dense brown scaling and pale recumbent scale-like setae ; the femora with a pale band on the thickest portion and each with a small tooth.

*Length*, 7–8 mm. ; *breadth*, 3.25–5 mm.

ORANGE FREE STATE : Bloemfontein, 1.xii.1916.

Described from eight specimens.

Found feeding on dahlias and chrysanthemums.



INJURIOUS SOUTH AFRICAN CURCULIONIDÆ.

- |   |   |
|---|---|
| 1. <i>Protostrophus noxius</i> , Mshl., sp.n. | 2. <i>Protostrophus instabilis</i> , Mshl., sp.n. |
| 3. <i>Eremnus horticola</i> , Mshl., sp.n.    | 4. <i>Protostrophus planatus</i> , Mshl., sp.n.   |



# A CONTRIBUTION TO KNOWLEDGE OF THE TABANIDAE OF PALESTINE.

By MAJOR E. E. AUSTEN, D.S.O.

At the present moment our knowledge of the Dipterous fauna, including the Tabanidae, of Palestine is little better than complete ignorance, consisting as it does solely of a few isolated records of species—chiefly mosquitos. The following paper, which it is intended shall be succeeded by others dealing with other families of Diptera, based upon material collected by the author in Palestine during the recent campaign against the Turks, is a modest attempt to lift one small corner of the veil of obscurity.

While, as in Syria according to previous writers,\* the dominant Dipterous family in Palestine is certainly the Bombyliidae,† the Tabanidae, of which twenty-one species are recorded or described in the ensuing pages, are by no means poorly represented. The extent to which the Dipterous fauna of Palestine is identical with that of Syria has yet to be determined, and the present writer unfortunately had no opportunity of pursuing his investigations north of Acre. So far, however, as the Tabanidae—the only family yet worked out—are concerned, Loew's remarks (*Verh. z.-b. Ges. Wien*, Bd. vii, 1857, p. 79) with reference to the Diptera of Syria would certainly apply to those of Palestine. "The Syrian Dipterous fauna," wrote the author in question, "is on the one hand so closely connected with that of Europe, and on the other exhibits so many peculiar species, that it merits a high degree of interest."

With the exception of three or four examples previously contained in the British Museum (Natural History), the material, amounting to one hundred and forty-four specimens, upon which the following paper is based was collected by the author, with occasional assistance from friends, during the Palestine Campaign of 1917-18. So far as possible, special attention was devoted to the collection of Tabanidae in 1918, owing to the prevalence early in that year of a rumour that, during 1917, the Turks in the Jordan Valley had lost a very large number of camels from surra, a form of trypanosomiasis of which the causative agent, *Trypanosoma evansi*, is at present believed to be capable of dissemination by more than one species of *Tabanus*. In view of the imperative necessity of maintaining a large mounted force in the Lower Jordan Valley until the date of the final general advance, the report in question at first caused some apprehension at General Headquarters, Egyptian Expeditionary Force. Fortunately, however, any fears that may have been entertained were not justified by the result, while the few cases

\* Bezzi (*Broteria*, Ser. Zool., Vol. viii, fasc. 2, 1909, p. 37), writing on Diptera from Syria, remarks:—"The peculiar character of the fauna is to be deduced from the multitude of Bombyliidae: this family is preeminent among all others owing to the beauty and wealth of its species, and constitutes 21·6 per cent of the entire collection." In a foot-note on the same page Bezzi points out that, among thirty-seven species of Syrian Diptera recorded by Loew ("Nachricht über syrische Dipteren," *Verh. z.-b. Ges. Wien*, Bd. vii, 1857, pp. 79-80), the Bombyliidae amount to 56·7 per cent.

† The material belonging to this family collected by the author in Palestine during 1917-18 consists of 289 specimens—nearly twice as many as those obtained belonging to any other family; the precise number of Tabanidae brought back was 136.



of surra diagnosed among animals belonging to the Camel Transport Corps failed to spread, and were by no means certainly contracted in Palestine.

While, somewhat curiously, no species of *Pangonia*\* was met with, and the large numbers of specimens of *Chrysops* encountered all proved to belong to the same species, the genus *Tabanus*, having regard to the relative smallness of the country concerned, was found to be decidedly rich in species. Of this genus, examples of no fewer than sixteen species were collected, and of these seven, or the high proportion of 43·7 per cent., are apparently new. With one exception, the remainder are more or less well known European forms, some of which have already been shown to occur further afield, as in North Africa, Asia Minor, or Persian Baluchistan. The applicability of Loew's generalisation, already quoted, concerning the Diptera of Syria, when transferred to those of Palestine, at least as represented by Tabanidae of the genus *Tabanus*, is therefore obvious.

Attention is directed to the pursuit of a fast travelling motor car by specimens of two species of *Tabanus* (cf. pp. 298, 300), one of which proved to be new. Some three months later, a second instance of the same phenomenon was seen under precisely similar circumstances, within a few miles of the same spot, the species concerned in this case being probably *Tabanus eggeri*, Schin., though, since no specimen was caught on this occasion, the identification is uncertain. In Nyasaland, tsetse-flies of the species known as *Glossina morsitans*, Westw., have been observed to pursue and keep pace with a motor cycle travelling at high speed, and the attraction exerted upon tsetse-flies by moving animals has been mentioned by more than one observer. So far, however, as the writer is aware, the pursuit of a motor car by Tabanids has not previously been recorded. It should be noted that the chase was confined to short distances, so that the chance establishment of a motor route passing through a local Tabanid area is unlikely to have much effect in extending the distribution of species.

It is only necessary to add that the whole of the material referred to in the following pages, including the types of all new species, is in the British Museum (Natural History).

#### PANGONIINAE.

##### Genus *Chrysops*, Meigen.

In so far as a definite conclusion is warranted by the author's necessarily limited observations, the form mentioned below would appear to be the only representative of its genus in Palestine. This paucity of species, however, is more than made up for by the relative ubiquity and absolute aggressiveness of the exemplar concerned.

##### *Chrysops punctifera*, Lw. (fig. 1).

Two ♀♀, Wadi Ghuzze, nr. Tel el Fara, 26.vi.1917, biting horse; 11 ♂♂, 6 ♀♀, same locality, 23.vii.1917, the ♂♂ numerous, resting on rocky bank of Wadi and on plants above pool, many ♀♀ ovipositing on reeds overhanging water; 3 ♂♂, 4 ♀♀, same locality, 8.viii.1917; 1 ♂, Deir el Belah, 8 miles S.-W. of Gaza, 31.viii.1917; 1 ♂, 1 ♀, Wadi Ghuzze, near El Gamli, 12.ix.1917; 2 ♀♀, Wadi Ghuzze,

\* Bezzi (*loc. cit.*, p. 41, Tab. ix, fig. 32) describes and figures, under the name *P. sulcata*, a new species of *Pangonia* from Syria.

nr. Tel el Fara, 14.ix.1917, biting author; 1♂, Wadi Ghuzze, nr. El Shellal, 19.ix.1917; 1♀, Wadi Ghuzze, nr. Tel el Fara, 28.ix.1917, biting author's arm; 1♂, Wadi Sukkerei, 10 miles S. of Jaffa, 13.iv.1918, ♂♂ alone seen; 1♀, Jericho Plain, nr. Kasr el Hajlah, 28.v.1918; 1♀, Latron, 18.vi.1918, biting author's hand; 1♀, left bank of R. Auja, nr. Sheikh Muannis, 5 miles N. of Jaffa, 29.vii.1918, biting author's arm; 1♀, Wadi Ishkar, R. Auja, nr. Ferekkiyeh, 8.viii.1918; 1♀, Wadi Barideh, nr. Sarona, 21.viii.1918, biting author's hand; 1♀, same locality, 2.ix.1918, biting author's arm; 2♀♀ (one biting author's arm), marshes bordering R. Kishon, nr. Haifa, 2.x.1918. In addition to the foregoing, the Museum already possesses a ♀ of this species from the "papyrus marsh above Baheiret el Hùleh (Waters of Merom), Upper Jordan Valley, 20.vii.1901" (the late Dr. J. Cropper), with the collector's field-note "only amongst papyrus."

In *Chrysops punctifera* the sexual colour-dimorphism, which is so striking a feature in the case of the majority of the palaearctic representatives of its genus, is especially pronounced, and at first sight it is difficult to believe that the predominantly ochreous or olive-ochreous\* female, with its brown-banded wings, can possibly be conspecific with the mainly black and largely black-winged male. This exceedingly aggressive and bloodthirsty fly would appear to be generally distributed throughout the entire country, and to occur wherever the necessary conditions for breeding exist. In July 1917, females were seen busily ovipositing



Fig. 1. Head of *Chrysops punctifera*, Lw., ♀, in profile, showing eye-markings. × about 14.

in the Wadi Ghuzze. The elongate eggs, which are white when newly laid and subsequently become opalescent brownish, are deposited in countless myriads, closely packed in sheets, on leaves of reeds overhanging pools of slowly flowing or stagnant water. The female of *Ch. punctifera*, wherever and whenever encountered, seems almost always ready to bite both man and domestic animals, and, so far as the author's personal experience goes, the species is more aggressive than any other Tabanid met with in Palestine.

\* For names and illustrations of colours used for descriptive purposes in the present paper, see Ridgway, "Color Standards and Color Nomenclature" (Washington, D. C. Published by the Author. 1912).

The range of the species extends at least into Syria. The type of *Chrysops punctifera*, Lw., which was originally described (*Neue Beiträge zur Kenntniss der Dipteren*, iv, 1856, p. 24) from the male alone, was obtained at Beirut. Subsequently (*Verh. k.-k. zool.-bot. Ges. Wien*, viii, 1858, p. 633) Loew, without giving precise indication of habitat, stated that he possessed nine males and three females of the species from "Syria," and added some notes on the female sex. Quite recently, during the preparation of this paper, the British Museum (Natural History) has received three males of *Ch. punctifera*, taken in Beirut Marshes, 11.iv.1919, by the donor, *Lt.-Col. E. P. Sewell, C.M.G., D.S.O., R.A.M.C.*

#### TABANINAE.

#### Genus *Haematopota*, Meigen.

The twenty-eight specimens of this genus obtained by the author in Palestine appear to belong to four species, none of which can be identified with any of those already known. They are accordingly described as new in the following pages, and an attempt has been made to construct a diagnostic table for their distinction. Since, however, all but three of the specimens are apparently conspecific, while the remainder, representing as many species, are exclusively females, it has been impossible to draw up a synoptic table for both sexes, and the subjoined key should be regarded as purely tentative.

Specimens of *Haematopota* were met with for the first time on 22nd April 1918, on horses near Jericho. None were encountered during the spring and summer of 1917, and their apparent non-occurrence in the Wadi Ghuzze is somewhat remarkable. A noteworthy instance of Syrphid-like hovering in the air by males of *Haematopota sewelli*, sp. n., is recorded on page 285.

#### *Key to Species described below.*

- 1(2). First joint of antenna, viewed from side, with a deep preapical groove\* on upper surface; femora largely greyish fawn-coloured or greyish cinnamon  
*sewelli*, sp. n. [1].
- 2(1). First joint of antenna without such a groove; femora entirely or mainly grey.
- 3(4). First joint of antenna, viewed from side, not at all swollen. Small or very small species .. .. . *minuscularia*, sp. n. [2].
- 4(3). First joint of antenna, viewed from side, distinctly or strongly swollen.
- 5(6). First joint of antenna, viewed from side, strongly swollen, its greatest vertical diameter greater than or fully equal to half the length of the joint; dorsum of abdomen with a broad, grey, border on each side  
*minuscula*, sp. n. [3].
- 6(5). First joint of antenna, viewed from side, moderately swollen but elongate, its greatest vertical diameter considerably less than half the length of the joint; dorsum of abdomen with a double row of grey spots, but without grey lateral borders .. .. . *innominata*, sp. n. [4].

\* Sometimes obscured by hair, in which case it may be difficult to distinguish. If, however, the head be examined from the left side, with a hand-lens magnifying about 5 diameters, the groove, if present though indistinguishable in the left antenna, can generally be seen distinctly on examining the inner side of the first joint of the right antenna.



**1. *Haematopota sewelli*, sp n. (figs. 2, 3).**

♂♀.—Length, ♂ (8 specimens) 11 to 12.2 mm., ♀ (17 specimens) 9 to 12.5 mm.; width of head, ♂ 4 to 4.4 mm., ♀ 3 to 4 mm.; width of front of ♀ at vertex 1.2 to 1.5 mm.; length of wing, ♂ 8.5 to 9.4 mm., ♀ 7.4 to 10 mm.

*Blackish (♂) or blackish brown, greyish olive, or deep greyish olive (♀) species, allied to and superficially closely resembling H. pluvialis, Linn.: distinguished in the ♂ by the hair on the upper and under sides of the first antennal joint being shorter and less fine, while the proximal half of the joint is entirely olive-grey pollinose, instead of the pollinose covering being confined chiefly to the upper and inner side of the proximal half or two-thirds; by the femora of all three pairs of legs in the ♂, or at least those of the middle pair, having a complete or incomplete tawny or ochraceous-tawny band, instead of all the femora being unicolorous dark neutral grey, iron grey, or dark olive-grey; by the first antennal joint in the ♀ being somewhat longer, usually slightly less swollen in proportion to its length, duller (mouse grey, dark neutral grey, or cinnamon-drab pollinose instead of partly shining black), and, if anything, more distinctly constricted before the tip, but with its upper surface not humped up before the constriction; and by the femora in the ♀ being largely greyish fawn-coloured or greyish cinnamon, instead of uniformly grey (deep olive-grey or neutral-grey).*

*Head:* front in ♀ smoke grey pollinose, clothed partly with short, erect, blackish hair, partly with pale yellowish hair, vertex with a pair of admedian, mouse grey or deep mouse grey blotches; frontal triangle in ♂ greyish olive, both sexes between and above bases of antennae with a large, dead black or blackish brown, hexagonal or quadrate spot, which in ♀ is bounded above by the frontal callus; face in ♂ pallid neutral grey pollinose, in ♀ whitish pollinose, in both sexes speckled with blackish brown on each side, in ♂ clothed on each side with fairly long blackish brown hair, in ♀ with a pair of small but fairly conspicuous, admedian, blackish brown spots below the antennae, and clothed with whitish hair; jowls whitish pollinose, clothed with whitish hair, part of which in ♂ sometimes has a yellowish tinge; occiput olive-grey, light olive-grey, or deep olive-grey, its upper margin fringed in ♂ with a mixture of fairly long, erect, blackish and yellowish hair, and in ♀ on each side of front with short yellowish hair; frontal spots in ♀ blackish brown or black, median spot usually small but distinct, lateral spots either roughly triangular or more or less rounded, not in contact with eyes; *frontal callus* in ♀ shining black, of moderate depth, its lateral extremities somewhat deeper and narrowly connected below with each eye, its upper margin produced in middle line into a small, upwardly directed angle; *eyes* in ♂ densely clothed with fine, erect, drab-grey hair, hairy covering of eyes in ♀ very short, but distinguishable under a hand-lens magnifying about 5 diameters, larger facets in ♂ contrasting conspicuously with those forming remainder of surface, but not coarse; proximal segment of ♂ *palpi* mouse grey or deep mouse grey, clothed with long whitish hair, terminal segment fairly large, ovate pyriform, pointed at distal extremity, greyish pollinose pinkish buff, usually with an ill-defined mouse grey blotch on outer side near base, clothed with whitish hair, which on upper margin beyond base is mixed with fine, erect, black or blackish hair; palpi in ♀ greyish pollinose pinkish buff, proximal segment sometimes with a mouse grey spot on outer side near



distal extremity, terminal segment moderately (in some specimens considerably) thickened towards base, proximal segment and base of terminal segment below clothed with fairly long whitish hair, terminal segment otherwise clothed on outer side with short, appressed, glistening pale yellowish hair, usually mixed on upper surface except at base, or at any rate towards distal extremity, with short, appressed, black hairs: first joint of *antennae* in ♂ considerably swollen, when viewed from above truncate ovate or elliptical ovate in outline, its distal half shining black; first joint of antennae in ♂ clothed below with yellowish white hair and above with black or blackish hair, except proximal portion of pollinose area at base, where hair is yellowish; second joint of antennae in ♂ blackish mouse grey, clothed with short and rather coarse black hair; expanded portion of third joint of antennae in ♂ of moderate depth as viewed from side, more or less greyish at base, cinnamon in middle, and dark brownish towards distal extremity, on inner side with a vertical band of minute, appressed, black hairs between blunt angle on upper border and lower margin; annulate portion of third joint of antennae in ♂ blackish brown, ending bluntly; first joint of antennae in ♀ thick, cylindrical, clothed with semi-appressed, short black hairs, lower surface, except distal extremity, clothed with longer whitish hair; second and third joints of antennae in ♀ as in ♂. *Thorax*: dorsum blackish brown (♂) or dark greyish olive (♀), in each case with pale smoke grey markings of the usual type; in ♂ these markings are but little conspicuous, and consist of a narrow median line, commencing on fore border but disappearing before reaching transverse suture, and a pair of admedian stripes, broader on anterior border but rapidly tapering off, interrupted before reaching transverse suture and reappearing behind latter in shape of a pair of more or less triangular spots resting on suture; markings in ♀ similar to foregoing, but in some specimens median line is continuous and reaches prescutellar groove, usual crescentic marks in front of latter are distinguishable, there is a broader pale smoke grey stripe on each side extending from inner extremity of depression at end of transverse suture to basal angle of scutellum, and lateral border on each side, from humeral callus to depression at end of transverse suture, and from latter to basal angle of scutellum is pale smoke grey; humeral calli in ♀, and swelling occupying depression at each end of transverse suture in same sex smoke grey; scutellum in each sex agreeing in coloration with ground colour of remainder of dorsum; pleurae and pectus in both sexes pale smoke grey pollinose and clothed with whitish hair (latter on mesopleurae in ♂ sometimes appears to have a yellowish tinge); dorsum, including scutellum, clothed in ♂ with fine, erect, yellowish hair, and in ♀ with short, appressed, glistening yellowish hair, which sometimes, especially towards lateral borders, appears to have a pinkish tinge. *Abdomen*: dorsum in ♂ dull black, posterior angles of first (visible) tergite and lateral extremities of two following tergites ochraceous-buff, ochraceous-tawny, or cinnamon, posterior margins of second and following tergites (in case of second, third, and fourth segments, and sometimes of fifth segment also, more or less distinctly expanded in middle line into a wide flattened triangle) dark olive-buff: second or third and following tergites to sixth inclusive in ♂ each with a pair of more or less distinctly marked greyish olive or deep greyish olive, rounded admedian spots (most distinct on fourth and two following segments), resting on

front margin in each case but usually not reaching or not quite reaching hind border, a certain number of the tergites indicated, at least the fourth to the sixth, also with a narrow median stripe of same colour as the spots; seventh tergite in ♂, except posterior and lateral margins, deep olive or dark olive, without spots or median stripe, lateral margins and posterior angles of third and following tergites of same colour as posterior margins; dorsum in ♂ clothed mainly with blackish hair, which in central region of first three and sometimes the following tergites also may be largely mixed with glistening yellowish or cream-buff hair, posterior angles of first and lateral extremities of two following tergites, posterior angles of fourth to seventh tergites inclusive, hind margins of sixth and seventh tergites and junction of median stripe with hind margin on the four preceding tergites



Fig. 2. *Haematopota sewelli*, Austen: a, head of ♂ from above; a', antenna of ♂ in profile; b, head of ♀ in profile.  $\times 14$ .

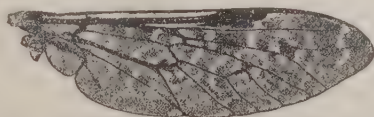


Fig. 3. *Haematopota sewelli*, Austen, wing of ♀.  $\times 6$ .

clothed with bright, glistening, cream-buff hair, downwardly curved lateral extremities of first tergite clothed with whitish hair; venter in ♂ mouse grey or deep mouse grey (seventh segment dark mouse grey), a larger or smaller area at lateral extremities of second and third segments light greyish pollinose ochraceous-salmon, hind margins of second and following segments light ochraceous buff; venter in ♂ clothed with fine, whitish or yellowish hair, seventh segment, except lateral extremities, with usual coarse, erect, black hair, central area of sixth segment usually with finer black hair; dorsum in ♀ blackish brown or dark blackish brown, each segment with a pair of relatively large, greyish olive or deep greyish olive, rounded, admedian spots, resting on front margin and not reaching hind border; latter, as well as posterior angles of each segment, a median, sub-triangular fleck

on first (visible) tergite, and a median longitudinal stripe on each of the following tergites, often indistinct or scarcely developed on seventh tergite but on the others expanded laterally at its junction with hind border (on second tergite so much expanded posteriorly that it has the shape of a median triangle), of same colour as the paired spots; lateral extremities of first two or three tergites pale smoke grey or deep gull grey, those of first (visible) tergite sometimes with a more or less distinct pinkish cinnamon fleck on each side; ground colour of posterior angles and hind margins of second or third and following tergites sometimes more or less distinctly cinnamon-buff or cream-buff; dorsum clothed on darker areas, as also on spots, with minute, appressed, black hairs, elsewhere clothed as a rule with appressed, glistening, cream-buff or cream-coloured hair; venter in ♀ light greyish olive, smoke grey or pale smoke grey pollinose, second and following segments each usually with a darker blotch in middle line, and with cream-buff or cream-coloured hind borders; venter in ♀ clothed with minute, appressed, glistening, yellowish or cream coloured hairs, last two segments mainly with erect black hairs, a few black hairs in centre of posterior half of antepenultimate segment also. *Wings* (fig. 3.) drab or light sepia-coloured; usual three rosettes, pale mark in marginal cell at distal extremity of stigma, and sinuous mark or transverse streak just before apex of wing (starting from costa at anterior distal angle of first submarginal cell) well developed and sharply defined; inner margin of proximal rosette as a rule perfectly distinct from (not fused with, as is often the case in the wing of *H. pluvialis*, Linn.) other pale marks crossing basal and anal cells; distal marginal angles of all posterior cells, or at least of second to fifth inclusive, often conspicuously pale; zig-zag pale mark running across proximal extremity of distal third of anal and axillary cells, as also loop in base of latter, well developed; discal cell with two pale transverse marks (portions of proximal and median rosettes) at each extremity; veins or portions of veins surrounded by centres of the three rosettes more or less distinctly infuscated; no conspicuous dark blotch beneath *stigma*; latter mummy brown or sepia-coloured, well developed, its proximal extremity pale. *Squamae* light drab (♂), with darker (drab-coloured) borders, or pale smoke grey (♀), with ivory yellow borders. *Halteres* cream-coloured, knobs clove brown at base above and below. *Legs*: coxae in ♂ neutral grey, clothed with long whitish hair; femora in ♂ deep mouse grey, or dark mouse grey, with a more or less conspicuous, complete or incomplete, tawny or ochraceous-tawny band round middle, present at least on middle pair, but sometimes absent in case of front femora and scarcely distinguishable on hind pair; femora in ♂ clothed with fine whitish hair, which is long behind and below; distal half of extensor surface of front femora in ♂, and extreme tips of same surface in hind pair clothed for most part with minute, appressed, black hairs; front tibiae in ♂ blackish brown, with a conspicuous cream-buff band just beyond base, and with distal two-thirds conspicuously or distinctly swollen; middle and hind tibiae in ♂ dark brown, each with two cream-buff bands, hind tibiae thickened; tibiae in ♂ clothed with black or blackish hair, which on middle and hind pairs is fairly long and fine, pale bands on all tibiae, as well as anterior surface of hind pair except distal extremities clothed with glistening cream-coloured or Naples yellow hair; front tarsi in ♂ black, middle and hind tarsi in same sex dark brown, first joints



of middle and hind tarsi, except distal extremities, cream buff, hairy covering of all tarsi black; front coxae in ♀ greyish pollinose cream-coloured or light drab, posterior surface and distal extremities usually neutral grey or light neutral grey, middle and hind coxae in ♀ pale neutral grey, all coxae clothed with whitish hair, longest in case of front pair, though front coxae sometimes show shorter, glistening, appressed, cream-coloured hairs on outer surface; femora in ♀ greyish fawn-coloured or greyish cinnamon, their extremities, at least distal extremities, more or less mouse grey or deep mouse grey; hairy covering of femora in ♀ as in ♂, but shorter; tibiae and tarsi in ♀ as in ♂, but hairy covering shorter.

Jaffa district; Lower Jordan Valley; near Tul Keram; and Acre.

Type of ♂ and five para-types belonging to the same sex, near Jerisheh, 5 miles N.-E. of Jaffa, 29.iv.1918; hovering at 9.0. a.m., poised in the air like Syrphids, in front of a tent on the outside of which two ♀♀ of the same species were resting. Type of ♀, same spot as foregoing, 5.v.1918. Additional para-types as follows:—2♂♂, same spot as before, 26.iv. and 5.v.1918 respectively; 9♀♀, Ain es-Sultan, near Jericho, 22.iv.1918, on horses; 4♀♀, same spot as that at which the typical specimens were taken, 29.iv. and—v.1918; one ♀, W. bank of R. Jordan, near Jericho, between El Ghoraniye and the Dead Sea; one ♀, Kerkar (between Tul Keram and Zimmarin), 28.ix.1918, biting author's arm; 1♀, marsh near Acre, close to mouth of Nahr Naamān (R. Belus), 5.x.1918—one of two specimens, one of which bit author's arm.

As a small acknowledgement of much kindness shown to the author, the species just described has been named in honour of his friend Lieut.-Col. (temp. Col.) E. P. Sewell, C.M.G., D.S.O., R.A.M.C. (late D.D.M.S., XXIst Corps, E. E. F.). So far as the experience of 1918 warrants such a conclusion, *Haematopota sewelli* would appear to be the commonest representative of its genus in Palestine. The remarkable habit of the males, referred to above, of remaining poised in the air like Hoverflies, although new to the present writer, would seem to be a generic character, since Schiner (Fauna Austriaca. Die Fliegen (Diptera), I. Theil, 1862, p. 38), at the end of his notes on the genus *Haematopota*, remarks:—"The males too hover in the air in the morning and towards evening."

## 2. *Haematopota minuscularia*, sp. n. (fig. 4, a).

♀.—Length (1 specimen) 6.6 mm.; width of head 2.6 mm.; width of front at vertex 1 mm.; length of wing 5.8 mm.

*Small, greyish black species, with somewhat elongate antennae, of which first joint is cylindrical, not swollen, and, when viewed from side, without a noticeable, groove-like constriction before its distal extremity; wings light drab, with all three rosettes well marked, adjacent margins of middle and proximal rosettes fused together where they cross discal cell, and with a pale border running along hind margin; femora, except extreme tips, which are narrowly warm buff, entirely grey, those of second pair of legs, at proximal ends of distal halves, each with a faint indication of a greyish fawn-coloured band.*

*Head:* front pale neutral grey, lateral margins, a narrow border encircling each frontal spot, and a narrow median line from vertex to median frontal spot paler



(pallid neutral grey); face and jowls pallid neutral grey pollinose, sides of face punctate in usual manner, but pair of dark spots on central region of face, seen in *H. sewelli*, Austen, ♀, absent or but faintly indicated; occiput pale neutral grey; with exception of a few minute black hairs in region of vertex, and on or near lateral frontal spots, hair on head entirely white; frontal spots dead black, median spot small but distinct, lateral spots large, circular, not in contact with eyes; *frontal callus* shining black, of moderate and practically uniform depth, narrowly in contact with eye on each side below, its upper margin, at least in case of type, not noticeably produced into an angle in middle line; usual spot in middle line below callus dull black, wider than deep, not conspicuous; *eyes* clothed with short whitish hair; proximal joint of *palpi* neutral grey, clothed with long white hair, terminal joint pale pinkish buff, not much swollen towards base, clothed with longer white hairs on proximal portion of under surface, and on outer side with minute, appressed, glistening creamy-white hairs, mixed towards distal extremity with minute black hairs; first joint of *antennae* olive-grey pollinose (shining black on outer and inner sides at distal extremity, which, though somewhat narrower than remainder of joint, is not marked off by a conspicuous constriction), clothed above and on

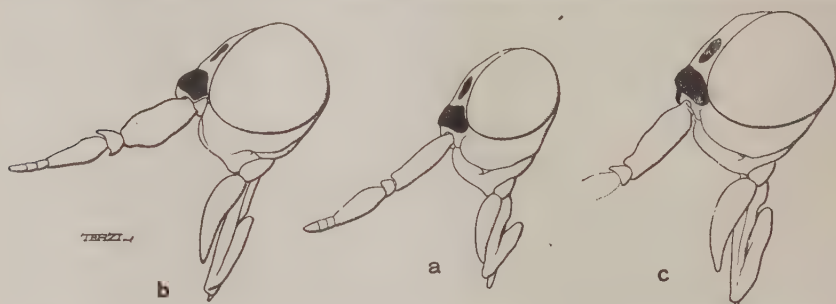


Fig. 4. *a*, *Haematopota minuscularia*, Austen; *b*, *H. minuscula*, Austen; *c*, *H. innominata*, Austen. Heads of ♀♀ in profile.  $\times 14$ .

outer side with very short, pale yellowish hairs, and below with longer white hair, second joint of antennae greyish brown, clothed with minute black hairs, third joint clove-brown, paler (cinnamon-brown) at extreme base, expanded portion as viewed from side not very deep, roughly elliptical in outline, longer than annulate portion. *Thorax*: dorsum blackish brown, clothed (including scutellum) with short, fine, yellowish or yellowish white hair, and marked with six, more or less distinct and continuous, pale olive-grey, longitudinal stripes, the two outer stripes on each side fused together in front of transverse suture, and behind latter much broader than remainder; scutellum with extreme base of outer border on each side, and a more or less indistinct median longitudinal stripe on upper surface pale olive-grey; pleurae and pectus pale olive-grey, clothed with long white hair. *Abdomen*: dorsum blackish brown, seventh tergite mouse grey, lateral borders and hind margins of first six tergites, as well as, on each segment from second to sixth inclusive, a median, forwardly directed triangle, based on hind margin and reaching or almost reaching front margin, and a pair of rounded, admedian spots, resting on or close to anterior margin, pale olive-grey; dorsum clothed with short,

appressed, whitish hair, except on blackish brown areas adjacent to median triangles on second to fourth segments inclusive, where hairy covering is black or blackish, and more erect; venter pale neutral grey, clothed with minute, appressed, creamy white hair, terminal segment with usual longer, coarse, erect, black hairs, extreme hind margins of second to sixth segments inclusive paler (pallid neutral grey or ivory yellow). *Wings*: light markings in distal half, at least in case of type, somewhat moniliform; pale border running along hind margin fairly deep, on distal side of each posterior marginal cell deeper than on proximal, commencing in second submarginal and terminating at base of axillary cell, in proximal half of which it becomes very narrow; owing to fusion of adjacent margins of proximal and middle rosettes, discal cell enclosing only three pale marks; inner margin of proximal rosette almost or quite in contact with other pale marks crossing basal, anal and axillary cells; sinuous mark at tip of wing not reaching pale hind border; *stigma* light sepia-coloured, paler at proximal extremity; veins or portions of veins surrounded by the three rosettes more or less distinctly infuscated. *Squamae* semi-hyaline, borders ivory yellow or cream-coloured. *Halteres* ivory yellow, knobs clove brown above and below. *Legs*: coxae and femora light neutral grey, clothed with whitish hair; front tibiae brownish black, with a fairly broad, creamy white band just beyond base, distal two-thirds conspicuously swollen, pale band clothed with glistening, appressed, cream-coloured hairs, a few of which pass over on to the brownish black portion, which is clothed otherwise with black hairs; middle and hind tibiae clove brown, clothed, except at distal extremities, chiefly with glistening, appressed, yellowish hairs, and each encircled with two cream-buff bands, distal extremities clothed with minute black hairs, hind tibiae somewhat thickened; front tarsi brownish black, clothed with black hair; middle and hind tarsi clove brown, first joints, except distal extremities, cream-buff.

Ain es-Sultan, near Jericho, 8.vi.1918, biting author's arm.

Apart from its small size, this tiny species can be distinguished, at least in the female sex, from all its congeners described or mentioned in the present paper by the shape of the first joint of the antenna.

### 3. *Haematopota minuscula*, sp. n. (fig. 4, b).

♀.—Length (1 specimen) 7.6 mm.; width of head 3 mm.; width of front at vertex 1.2 mm.; length of wing 6.2 mm.

*Dorsum of thorax olive, with lateral borders and three narrow, incomplete, longitudinal stripes pale smoke grey; dorsum of abdomen with black, median, longitudinal stripe (tapering and becoming olivaceous black towards distal extremity), and with lateral borders broadly olive-grey; first joint of antennae strongly swollen; wings light drab, with usual pale markings well developed, and those in discal cell as in H. pluvialis, Linn.*

*Head*: front deep olive-grey, lateral margins and a ring encircling each lateral frontal spot pale smoke grey, a median stripe extending from margin of occiput at vertex to median frontal spot, and a small ring encircling latter, light olive-grey: face and jowls pale gull grey, sides of face punctate in usual manner, but pair of dark spots on central region of face, seen in *H. sewelli*, Austen, ♀, and *H. pluvialis*,

Linn., ♀, absent; occiput light olive grey, upper border darker (greyish olive); with exception of a few minute black or blackish hairs on front above median frontal spot, and between upper extremities of inner sides of lateral frontal spots, hair on head entirely pale, that on front and fringe of occiput above with a distinct yellowish tinge, hair on face and jowls white; frontal spots dead black, median spot distinct, lateral spots large, roughly oval, not in contact with eyes; *frontal callus* shining black, of moderate and practically uniform depth, narrowly separated from eye on each side, and with upper margin produced in middle line into an upwardly directed angle; spot in middle line below callus dull black, triangular or wedge-shaped in outline (narrower below); *eyes* clothed with minute, pale hairs; *palpi* light buff, clothed with white hair, proximal joint light neutral grey on outer side towards base, terminal joint slender, elongate and acuminate, as viewed from side only slightly swollen towards base; first joint of *antennae* shining black, neutral grey pollinose on upper surface of proximal half, elliptical oval in outline as seen from above, as viewed from side thickest a short distance before distal extremity, but *without groove-like constriction* before latter exhibited by both *H. phuvialis*, Linn., ♀ and *H. sewelli*, Austen, ♀ (*vide supra*); first joint of antennae, except distal extremity, clothed above and on upper part of outer surface with glistening yellowish hair, and below with longer white hair, distal extremity clothed with black hair; second joint of antennae pale (light drab on outer side, inner surface greyish pollinose light ochraceous buff), distal angles clothed above and below with black hairs; expanded portion of third joint of antennae clove brown (base paler—ochraceous tawny), elongate and tapering, moderately expanded a little beyond base, annulate portion brownish black, shorter than expanded portion. *Thorax*: dorsum, including scutellum, clothed with partly appressed, partly erect, glistening pale yellowish or whitish hair of medium length, hair on front border whitish, somewhat longer and more erect; fore border of dorsum pallid neutral grey; median pale smoke grey longitudinal stripe extending from fore border to a point two-thirds of distance between transverse suture and prescutellar groove; admedian pale smoke grey longitudinal stripes not reaching transverse suture, but each reappearing behind latter in usual shape of a triangular spot resting on suture; pale smoke grey lateral border on each side partially divided behind transverse suture into two longitudinal stripes; swelling occupying depression at each end of transverse suture clothed below with fairly long and fine blackish hair; pleurae and pectus pale smoke grey, and clothed with fine white hair. *Abdomen*: black median longitudinal stripe on dorsum not sharply defined on first (visible) tergite, attaining its greatest breadth (one-third of transverse diameter of segment) on second tergite and thereafter becoming progressively narrower, scarcely distinguishable on seventh tergite, ground-colour of which is mouse grey; hind margins of second and following tergites, as well as, on second to sixth segments inclusive, a more or less distinct narrow median line light greyish olive; inner edge of olive-grey lateral border on each side of each segment formed by a large rounded grey spot, in contact with anterior border of each segment and on first three segments more or less completely fused with lateral border, while on last four segments it may be partly or completely separated therefrom, in which case the spot is partly surrounded with blackish brown;



dorsum clothed on basal angles and on extreme lateral margins of first four segments with fine white hair, clothed otherwise on grey lateral borders with minute, appressed, glistening yellowish hairs (longer on hind margins of last three segments, and on spots on fourth to sixth segments inclusive partly or entirely replaced by minute black hairs), black or olivaceous black areas clothed for most part with minute black hairs; venter smoke grey, hind margins of second and following segments ivory yellow, third to sixth segments inclusive and posterior portion of second segment clothed with minute, appressed, yellowish hairs, central portion of seventh segment clothed as usual with longer, coarse, erect, black hair. *Wings*: outer borders of rosettes somewhat broken up, apical sinuous mark (pale transverse streak just before apex of wing) well developed and (at least in the type) reaching hind margin; distal extremity of each posterior marginal cell occupied by a large, somewhat wedge-shaped pale blotch, posterior margin of axillary cell, from distal extremity to fused ends of zig-zag transverse pale marks, also pale, so that hind margin of wing has a deep pale border, interrupted at proximal marginal angles of posterior marginal cells (broken up into a series of blotches); *stigma* light sepia-coloured, not very noticeable, paler at proximal extremity. *Squamae* milk white, borders ivory yellow. *Halteres* ivory yellow, knobs with a seal brown spot at base above and below. *Legs*: coxae and femora neutral grey, clothed with white hair, distal extremities of front and hind femora above and below and of middle femora above clothed with black hairs, which also cover rather less than distal half of antero-superior surface of front femora; extreme tips of all femora cream-buff, middle femora with a more or less distinct, complete or incomplete, light greyish cinnamon band, occupying approximately middle third: front tibiae brownish black, with a fairly broad cream-coloured band just beyond base, distal two-thirds conspicuously swollen, pale band clothed with glistening, appressed, yellowish hair, front tibiae otherwise clothed with black hair; middle and hind tibiae clove brown, middle tibiae with extreme base and two bands cream-coloured, hind tibiae with extreme base and two bands cream-buff, hair on middle and hind tibiae mainly black on dark areas, glistening cream-coloured or yellowish on pale bands, inner surface of hind tibiae clothed mainly with minute, appressed, glistening, yellowish hairs, extensor surface of middle tibiae sparsely fringed with long, pale hairs; front tarsi black, clothed with black hair, third and fourth joints somewhat expanded; middle and hind tarsi clove brown or blackish brown, clothed with minute black hairs, first joints, except distal extremities, cream-buff or cream-coloured, second, third, and fourth joints also narrowly pale at extreme base.

Jericho Plain, near Makhadet Hajlah, R. Jordan, 9.vi.1918, biting mule.

The predominance of pale hair on the front in the ♀, the pale second antennal joint, and the markings of the dorsum of the abdomen and of the discal cell in the wing—the latter agreeing with those seen in the wing of *Haematopota pluvialis*, Linn.—will serve to distinguish the species described above, at least in the female sex, from *H. crassicornis*, Whlbg., with which it agrees in the absence of a groove-like constriction before the distal extremity of the first joint of the antennae.

So far as it is possible to judge from the original description of *Haematopota pallens*, Lw., the typical specimens of which were obtained in Turkestan,



*H. minuscula* resembles that species, especially in the markings of the abdomen and wings, but is distinguishable, *inter alia*, by its smaller size, by the less elongate antennae, and by the more swollen first antennal joint.

4. ***Haematopota innominata*, sp. n.** (fig. 4, c).

♀.—Length (1 specimen) 9 mm.; width of head 3.25 mm.; width of front at vertex 1.2 mm.; length of wing 7.5 mm.

*Dorsum of thorax* dark olive, with lateral borders and three narrow, complete, longitudinal stripes pale smoke grey or smoke grey; *dorsum of abdomen* black, each segment from second to seventh inclusive with hind border, a more or less distinct median stripe (practically obsolete on third segment in the type), and a pair of rounded spots (relatively small as compared with corresponding spots in *H. sewelli*, Austen, ♀—vide supra, p. 283) light olive-grey; *first joint of antennae* as seen from side distinctly incrassate, roughly elliptical, somewhat narrower in middle, narrowed at each extremity, but without a sharply marked preapical groove.

*Head*: front deep mouse grey, posterior angles, border of occiput, a narrow border surrounding median frontal spot, and a median stripe connecting latter with occipital margin pale neutral grey, extreme lateral margins and a narrow ring surrounding each lateral frontal spot pale smoke grey; face and jowls pale gull grey or whitish, sides of face punctate in usual manner, pair of dark spots on central region of face, seen in *H. sewelli*, Austen, ♀, and *H. pluvialis*, Linn., ♀, faintly marked; occiput pale neutral grey; hair on front mainly dusky (blackish brown or blackish), that on margin of occiput pale yellowish and short, upper margin of frontal callus partly concealed by a downwardly directed fringe of fairly long, appressed, glistening whitish hair, face and jowls clothed with white hair; frontal spots dead black, median spot small but distinct, elongate (fusiform or elliptical), lateral spots large, bluntly triangular, at least in type, not in contact with eyes; *frontal callus* shining black, of relatively considerable and practically uniform depth, in contact with eye on each side below, but with its upper margin scarcely produced into an angle in middle line; spot in middle line below callus dull black, truncate triangular, narrower below; *eyes* sparsely clothed with minute, pale hairs; proximal joint of *palpi* neutral grey on outer surface and clothed with whitish hair, terminal joint light buff, clothed below at base with fairly long and, on outer side with short, appressed, glistening whitish hair, mixed on outer surface beyond proximal fourth with minute black hairs, terminal joint acuminate, proximal half, at least in type, considerably swollen; first joint of *antennae* neutral grey pollinose (narrower distal extremity shining black), clothed above and on inner side with short black hair, on upper part of outer side with short whitish hair, and below, especially on proximal half, with longer whitish hair; second joint of antennae blackish brown, clothed with black or blackish hair (third joint missing in case of type). *Thorax*: dorsum clothed with short, partially appressed, glistening yellowish hair, dorsal surface of scutellum clothed with longer and more erect hair of same kind; median longitudinal smoke grey stripe very narrow, admedian stripes broader, but tapering to transverse suture and becoming partly obsolete midway between latter and prescutellar groove, pale smoke grey lateral border, behind depression at each end of transverse suture, indistinctly divided

into two fairly broad longitudinal stripes by means of an olive streak; scutellum with an ill-defined olive-grey median stripe, and base of each lateral border light olive-grey; swelling occupying depression at each end of transverse suture clothed below with fine blackish hair; pleurae and pectus light neutral grey, clothed with whitish hair. *Abdomen*: first (visible) tergite without either median stripe or rounded spots, otherwise agreeing in coloration with following tergites, rounded spots on fourth and subsequent tergites resting on base of segment, and in each case partly concealed by hind margin of preceding tergite; lateral extremities of first and second tergites pale neutral grey, those of first tergite clothed with fine white hair, lateral extremities and posterior angles of third and following tergites and hind borders of all tergites clothed with fine, glistening pale yellowish or yellowish white hair, longer than elsewhere on posterior angles of fifth and sixth tergites, and on hind borders of last two segments; dorsum otherwise clothed with minute, appressed, black hairs, second tergite with an area of minute, appressed yellowish hairs extending from in front of each rounded spot towards posterior angle on each side, spots on third tergite and area in front of them partly clothed with similar hairs; venter olive-grey, median third of last three scutes darker (mouse grey), hind margins of second and following segments pale olive-buff; ventral surface, except last segment, clothed with minute, appressed, yellowish hairs, terminal segment clothed as usual with coarse, erect, black hairs, a few black hairs also on preceding segment. *Wings* as in *H. sewelli*, Austen; distal margins of rosettes moniliform; posterior margin of wing with a rather narrow, interrupted, pale border, extending from distal extremity of first posterior cell almost to middle of axillary cell, somewhat faint in distal extremity of first posterior cell, and in each subsequent posterior cell broader in distal marginal angle and tapering towards proximal marginal angle, where it becomes indistinct; *stigma* mummy brown, well marked, its proximal extremity pale. *Squamae* pale smoke grey, borders ivory yellow. *Halteres* ivory yellow, knobs seal brown above and below. *Legs*: coxae and femora light neutral grey or neutral grey, clothed with glistening whitish or silvery white hair, extreme tips of femora as usual cream-buff; front tibiae brownish black, with a fairly broad cream-coloured band just beyond base, distal two thirds conspicuously swollen, pale band clothed with glistening, appressed, silvery white hair, front tibiae otherwise clothed with black hair; middle and hind tibiae clove brown, each with two cream-buff or cream-coloured bands and largely clothed with minute, glistening, yellowish hairs, fringes on antero-extensor margins of hind tibiae consisting of rows of black and yellowish hair alternately; front tarsi black, clothed with black hair; middle and hind tarsi blackish brown, clothed with minute black hairs, proximal two-thirds of first joint in each case cream-buff or cream-coloured.

Near Jerisheh, 5 miles N.-E. of Jaffa, first week of May 1918.

The species just described is allied to *Haematopota pluvialis*, Linn., and *H. sewelli*, Austen, but is distinguished from both in the female sex by the first joint of the antenna being less swollen and more elongate, with the groove-like constriction before the distal extremity less sharply marked, although the extremity itself is narrowed. *Haematopota innominata*, ♀, is further distinguished from *H. sewelli*, ♀, by the dorsum of the abdomen being blacker, owing to the much less extensive

development of the grey markings; and by the femora, except the extreme tips, which as usual are cream-buff, being entirely neutral grey, without any trace of greyish fawn-coloured or greyish cinnamon markings.

From *Haematopota minuscularia*, Austen, ♀, *H. innominata*, ♀, is distinguishable owing to its larger size, the hair on the front being mainly blackish or blackish brown, the first joint of the antenna, as viewed from the side, being very distinctly swollen and less conspicuously greyish pollinose, and by the grey markings on the dorsum of the abdomen being much less extensive.

Lastly *Haematopota innominata*, ♀, may be distinguished from *H. minuscula*, Austen, ♀, by the first joint of the antenna being less swollen and more elongate, and by the absence of broad, grey, lateral borders to the dorsum of the abdomen.

### Genus *Tabanus*, Linn.

The seventy specimens of this genus obtained by the author prove, as already stated, to belong to sixteen species, of which seven, or 43·7 per cent—a fairly high proportion—are apparently new. The list of species is as follows:

1. *Tabanus decorus*, Lw.
2. „ *alexandrinus*, Wied.
3. „ *insecutor*, sp. n.
4. „ *gigas*, Herbst.
5. „ *mendicus*, Villen.
6. „ *lunatus*, Fabr.
7. „ *nemoralis*, Mg.
8. „ *eggeri*, Schin.
9. „ *autumnalis*, Linn.
10. „ *regularis*, Jaenn.
11. „ *rupinae*, sp. n.
12. „ *arenivagus*, sp. n.
13. „ *accensus*, sp. n.
14. „ *leleani*, sp. n.
15. „ *pallidipes*, sp. n.
16. „ *dalei*, sp. n.

The representatives of *Tabanus gigas* and *T. autumnalis* show variations in coloration already noticed more than sixty years ago by Loew (*Verh. z.-b. Ges. Wien*, Bd. viii, 1858, pp. 582–583, 605), in the case of examples from Sicily, Cyprus, or Asia Minor. In particular, the russet tint of the ground-colour of the dorsum of the abdomen in females of *T. autumnalis*, Linn., makes the recognition of such individuals a matter of some difficulty for those who are only familiar with the form of the species usually seen in Northern and Central Europe, in which the abdomen in the female is black or blackish mouse grey.

While all of the previously described species of *Tabanus* met with in Palestine are purely palaearctic, and the entire Tabanid fauna appears free from any admixture of Oriental or Ethiopian forms, certain of the more or less grey or drab-coloured species described below as new, such as *T. leleani*, *T. arenivagus*, and *T. rupinae*, appear to some extent to show the influence of a desert environment.



*Key to the Sixteen Species of Tabanus recorded below.\**

- 1 (11). Eyes (under an ordinary hand lens magnifying about 5 diameters) distinctly or conspicuously hairy.
- 2 (3). Body uniformly black, unrelieved by conspicuous lighter markings formed by hair or ground-colour, or both; wings blackish brown, or with veins strongly suffused with that colour .. .. *alexandrinus*, Wied. [2].
- 3 (2). Body not uniformly black, if mainly black or slate-black invariably relieved by lighter markings formed by hair or ground-colour, or both; wings not blackish brown.
- 4 (5). Dorsum of abdomen with greyish olive median longitudinal stripe  
*lunatus*, Fabr. [6].
- 5 (4). Dorsum of abdomen not so marked.
- 6 (7). Dorsum of abdomen with three longitudinal series of clearly defined, pale neutral grey, white haired or whitish haired spots, those of median row triangular .. .. *nemoralis*, Mg. [7].
- 7 (6). Dorsum of abdomen not so marked.
- 8 (9). Large or very large species, at least 18 mm. in length; dorsum of thorax, including scutellum, densely clothed with bright ochreous or yellowish hair .. .. *gigas*, Herbst [4].
- 9 (8). Small or medium-sized species, not exceeding 14 mm. in length.
- 10(11). Second (visible) abdominal tergite in both sexes with a double, quadrate, black or blackish mouse grey mark, occupying median third and partly divided by an indistinct greyish triangle, based on hind margin  
*decorus*, Lw. [1].
- 11(10). Second (visible) abdominal tergite not so marked.
- 12(13). Legs in ♀ (only sex at present known), except extreme tips of femora, entirely black or slate-black; no sharply marked contrast between first two abdominal tergites and the two following ones .. *insecutor*, sp. n. [3].
- 13(12). Legs in ♀ (only sex at present known) not entirely black, extreme base of extensor surface of front tibiae, and middle and hind tibiae and first joint of middle and hind tarsi except tips, cream-buff; first two abdominal tergites in ♀ greyish olive pollinose, clothed with fairly long ochreous hair, and, especially when viewed from the side, contrasting sharply with next two tergites, which are shining black  
*mendicus*, Villen. [5].
- 14 (1). Eyes (under an ordinary hand-lens magnifying about 5 diameters) bare or apparently so.

\* In this table, as in that for the genus *Haematopota* above, contrasted and mutually exclusive statements and summaries of characters are indicated by the paired numbers on the left, the contrasted conditions in each case being shown, either subsequently or previously, under the second number of the pair (i.e., the one in round brackets).

The number in square brackets [ ] after the name of a species indicates the serial position of the species in the ensuing pages.

It should be noted that the characters of a given species shown in the table are only sufficient to distinguish it from the other species included in the present synopsis; they are not necessarily distinctive as regards known species not yet met with in Palestine, but which may ultimately prove to form part of its fauna.

*Tabanus insecutor*, sp. n., is shown twice in the table, since it is included in both the hairy-eyed and bare-eyed categories the very minute hairs on the eyes in the ♀ being liable to be overlooked on a first examination.



- 15(16). Blackish species. Dorsum of abdomen slate-black, transversely banded with silvery-white hair; wings with extreme base and proximal two-thirds of costal border ochraceous-tawny, contrasting sharply with remainder of surface .. .. . *dalei*, sp. n. [16].
- 16(15). Not blackish species. Dorsum of abdomen not slate-black, but with markings arranged in longitudinal series; no part of costal border presenting a sharp colour contrast to remainder of wing.
- 17(18). Conspicuously narrow-bodied, elongate species.
- a) Frontal triangle in ♂ and subcallus in ♀ with shining transverse band, extending from eye to eye .. .. . *arenivagus*, sp. n. [12].
- b) Frontal triangle in ♂ and subcallus in ♀ without shining transverse band, entirely dull, pollinose .. .. . *accensus*, sp. n. [13].
- 18(17). Species of ordinary shape, not conspicuously narrow-bodied or elongate.
- 19(20). Dorsum of abdomen with median longitudinal stripe.
- a) Ground-colour of dorsum of abdomen ochraceous tawny .. .. . *rupinae*, sp. n. [11].
- b) Ground-colour of dorsum of abdomen blackish brown; much smaller species than foregoing (length of ♀ 13.5 to 14 mm.) .. .. . *regularis*, Jaenn. [10].
- 20(19). Dorsum of abdomen without median longitudinal stripe.
- 21(22). Legs in ♀ (only sex at present known), except extreme tips of femora, entirely black or slate-black .. .. . *insecutor*, sp. n. [3].
- 22(21). Legs not entirely black or slate-black, at least proximal half of front tibiae, and middle and hind tibiae except tips, pale (cream-buff or ochraceous buff).
- 23(24). Femora cinnamon-buff or pinkish cinnamon .. .. . *pallidipes*, sp. n. [15].
- 24(23). Femora, at least front pair, black or blackish, neutral grey or pale neutral grey pollinose.
- 25(26). Mouse grey, dark mouse grey or blackish mouse grey species; front in ♀ broad (its length equal to rather less than four times its breadth at lower margin of lower callus), with two large and completely separate frontal calli, the lower callus large, quadrate, broader than high *leleani*, sp. n. [14].
- 26(25). Not mouse grey species; front in ♀ narrow or of only moderate breadth (its length equal to at least five times its breadth at lower extremity), upper callus represented only, if at all, by a narrow median line running upwards from lower callus, latter narrow, elongate, usually tapering to its upper extremity, two and a half to three times as high as its breadth below.
- 27(28). Sides of pale triangles in middle line of abdomen not concave; first posterior cell in wing greatly narrowed (sometimes even closed) at or before its distal extremity; front in ♀ at least seven and a half or eight times as long as its breadth at lower extremity; venter, except extreme tip, and a broad, median, longitudinal, shining, slightly or not at all infuscated stripe, uniformly light ochraceous-salmon or light ochraceous-buff: large species, at least 19 or 20 mm. in length .. .. . *eggeri*, Schin. [8].

- 28(27). Sides of pale triangles in middle line of abdomen usually more or less concave; first posterior cell in wing, though often narrowed at distal extremity, seldom exceptionally so; front in ♀ five or five and a half times as long as its breadth at lower extremity; ground-colour of dorsum of abdomen in ♀ either russet, black, or blackish grey—if russet, then venter pale smoke grey pollinose orange-cinnamon or pinkish cinnamon, without or with but faintly indicated, broad, dark, median, longitudinal stripe: fairly large or large species, 15 to nearly 19 mm. in length  
*autumnalis*, Linn. [9].

### 1. *Tabanus decorus*, Lw.

One ♂, three ♀♀, near Jerisheh, 5 miles N.-E. of Jaffa, between 26.iv. and 8.v.1918; one ♀, Valley of Jehoshaphat, Jerusalem, 20.iv.1918 (*Captain (acting Lt.-Col.) W. J. Dale, O.B.E., R.A.V.C.*).

Notwithstanding that the third joint of the antenna in three of the ♀♀ mentioned above (it is wanting in the other two specimens) is somewhat broader than it should be, according to Loew's own statement and the subsequent description by Brauer (*Denkschr. k. Akad. Wiss.*, xlii, 1880, pp. 152-153), there can be little doubt that the determination here given is correct. The eye-markings in this species appear to be in course of disappearance, and to be somewhat variable in consequence. Loew and Brauer describe the eyes as unbanded in the ♂, but as having in the ♀ a single, narrow, greenish-yellow transverse band, or an indistinct trace of such a band. The ♂ mentioned above, and one of the ♀♀ taken at Jerisheh, had in life green eyes, each marked with a single, faint, narrow, median, golden horizontal band; while another ♀ captured at the same spot had bronze-green eyes, each with three faint, golden, transverse bands, the middle one being the more distinct.

It may be added that the type of *Tabanus decorus* was taken in Syria, while Brauer (*loc. cit.*) records the species as occurring in the Lebanon.

### 2. *Tabanus alexandrinus*, Wied. (fig. 5.).

Five ♂♂, three ♀♀: near Jerisheh, 5 miles N.-E. of Jaffa, 26.iv.1918 (one ♂ beginning of May).

Although the brevity and lack of precision of the original description (*Aussereurop. zweifl. Ins.*, ii, 1830, p. 624) of this entirely black species would render identification difficult, there can be no doubt, in spite of a slight discrepancy as regards the coloration of the eyes, that the specimens referred to above really belong to *T. alexandrinus*, as characterised and redescribed by Brauer (*Denkschr. k. Akad. Wiss.*, Bd. xlii, 1880, p. 161, Taf. ii and v, figs. 23). This author records the species as occurring in Syria and Italy, and states that Wiedemann's collection contains examples of it from Alexandria. A distinctive character of the typical form of *T. alexandrinus*, especially in the ♀, is the shape of the expanded portion of the third joint of the antenna, the upper margin of which is convex, or at least shows no trace of the usual excavation (fig. 5). The expanded portion of the third antennal joint varies in width in different individuals, and is sometimes, especially in the ♂, a good deal narrower than it appears in the figure. Macquart (*Hist. Nat. Ins., Dipt.*, i, 1834, p. 199), who redescribed the species under the name *Tabanus*

*carbonatus*, from a specimen from Sicily, notes the shape of the upper margin of the third antennal joint.

According to Brauer (*loc. cit.*), the eyes in both sexes are dark green; in the specimens collected near Jerisheh, however, the eyes of ♂ and ♀ in life were unicolorous black.

The Museum collection contains several examples (2 ♂♂, 3 ♀♀), from Algeria and Tunis, of what must, at any rate provisionally, be regarded as a variety or local race of the present species.\* This western form is distinguished from the typical one, as represented by Palestine specimens, by the absence of the greyish-white hairs on the lateral margins of the dorsum of the thorax in the ♀, on and in front of the postalar calli, and by the distal extremity of the expanded portion of the third joint of the antenna being distinctly emarginate above. This is at any rate the case in the ♀; in the two ♂♂ from Algeria and Tunis the third joints of the antennae are unfortunately missing.

Brauer's record of *Tabanus alexandrinus* from Syria, referred to above, gives no more precise indication of locality, but Bezzi (*Brotéria*, Ser. Zool., viii, 1909, p. 42) records the species as having been taken at Ghazir (about 15 miles N.-E. of Beirut), on 14th June, 1904.

It is interesting to note that clinging to the hair clothing the front coxae of one of the ♂ specimens taken near Jerisheh on 26th April 1918, were six little, hexapod, *Campodea*-like larvae, which Dr. Gahan states are the "triungulin" stage of an oil-beetle (*Meloe* sp.).

### 3. *Tabanus insecutor*, sp. n. (fig. 6).

♀.—Length (1 specimen) 12.25 mm.; width of head 4 mm.; width of front at vertex 0.6 mm.; length of wing 10.25 mm.

Eyes unbanded, at first sight appearing bare, when more closely examined seen to be sparsely clothed with very short, very minute hairs; dorsum of thorax shining blackish mouse-grey pollinose; dorsum of abdomen shining black, clothed partly with minute appressed black hairs, and on hind borders of second and following segments with appressed glistening whitish or pale ochreous hair, first and second tergites and hind borders of two following segments greyish pollinose; frontal callus of ♀ large, elongate, shining black; palpi dark neutral grey, terminal segment in ♀ slender; first two joints of antennae dark neutral grey, third joint black, expanded portion broad, its upper margin angulate; wings lightly tinged with brownish drab, extreme base and costal border as far as stigma ochre-coloured, a small, ill-defined, oblique, faint cinnamon-brown blotch extending from narrow, elongate, ochraceous-tawny stigma to discal cell; legs, except extreme tips of femora, which are cinnamon-buff, entirely black or slate-black.

\* The ♂ genitalia of this North African form have been examined microscopically and compared with those of the typical race, as found near Jerisheh; a similar comparison has been made in the case of the infra-anal plate of the ♀. The differences noted in each instance appear to be merely trivial, and, so far as the limited material available for study permits a definite conclusion to be drawn (a pair of specimens of each form is all that can at present be devoted to dissection), cannot be regarded as anything more than individual.



*Head* light neutral grey pollinose, face and jowls somewhat thinly clothed with whitish hair, longer in basi-occipital region, hind margin of occiput fringed above and at sides with very short, pale yellowish hair; *front* in ♀ of medium and entirely uniform width, about three and a half times as long as broad, clothed with minute, appressed, glistening ochreous or pale yellowish hair, ground-colour slightly darker in region of vertex but no trace of an ocellar tubercle; lower and upper *frontal calli* fused together to form a single, elongate, shining black callus, extending from level of inner angles of eyes to a point slightly more than one-third of length of front from hind margin of vertex; callus exhibiting a trace of a fine, elongate, median groove, and separated from eye on each side by an interspace equal to rather less than half its width, lower margin of callus straight, upper extremity ogival, the middle region somewhat constricted, so that outline of entire callus is suggestive of that of an Ancient Greek, leaf-shaped sword; *eyes* of ♀ *in life* plain dark green, unbanded; proximal segment of *palpi* clothed with whitish hair, distal segment in ♀ acuminate, sparsely clothed on outer surface with minute, appressed, yellowish hairs; first two joints of *antennae* clothed above and below with short black hairs, first joint not swollen and not embracing second joint, upper distal angle of latter moderately produced, annulate portion of third joint about one-fourth shorter than expanded portion, depth of latter, from centre of lower margin to apex of angle on upper border, about equal to its length, angle, which bears a few exceedingly minute black hairs, situate in centre of upper border, which is slightly emarginate in front of it. *Thorax*: dorsum (including scutellum) and pleurae clothed with pale ochreous or pale yellowish hair, the hairy covering of the pleurae almost whitish at the tips, lateral borders of dorsum and commencement of two longitudinal stripes extending a short distance from front margin cinereous pollinose. *Abdomen*: first and second (visible) tergites clothed with glistening appressed, pale ochreous hair, the hair forming a tuft in the centre of the hind border of the first tergite paler, and that on the hind border of the second tergite glistening whitish; glistening, appressed, pale hair on hind borders of fifth and sixth segments extending forwards in middle line in each case in form of a broad triangle, apex of which is almost or quite in contact with hind margin of preceding segment; sides of sixth tergite and entire surface of seventh clothed with glistening, appressed, pale ochreous or pale yellowish hair; ground colour of seventh tergite cinereous pollinose; venter blackish slate-coloured, neutral grey pollinose but moderately shining, clothed with short, glistening, appressed, pale ochreous or pale yellowish hair, extreme hind margins of second and following scutes cream-buff. *Wings*: proximal portions of first and fifth longitudinal veins ochraceous tawny, bases of second and sixth veins ochreous, veins otherwise dark mummy-brown or dark sepia-coloured, anterior branch of third longitudinal vein without an appendix. *Squamae* light buff, fringed with pale hair. *Halteres*: knobs dark seal-brown above and below, stalks and tips of knobs cream-buff or cinnamon-buff. *Legs*: coxae neutral grey pollinose, both they and femora clothed with fine, yellowish hair; tarsi and tips of tibiae, as also inner sides of front pair of latter, clothed with minute, appressed, black hairs, tibiae elsewhere clothed with short, glistening, appressed, yellowish-white, pale yellowish, or pale ochreous hair; front tibiae slightly thickened.



Near Mulebbis (Jaffa district), 14.v.1918 : caught by *Lt.-Col. E. P. Sewell, C.M.G., D.S.O., R.A.M.C.*, from a light Ford motor-car (which the insect was pursuing) travelling at 20 miles an hour across a grassy plain ; more than one specimen seen.

Apart from its smaller size, the species just described presents a superficial resemblance to *Tabanus aterrinus* var. *auripilus*, Mg., but is distinguishable, *inter alia*, by the elongate frontal callus of the ♀, and by the conspicuously ochreous coloration of the base of the wing.

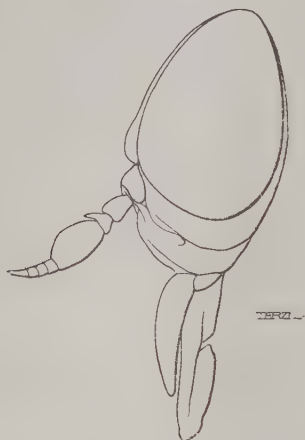


Fig. 5. *Tabanus alexandrinus*, Wied., head of ♀ (typical form) in profile.  $\times$  about 10.

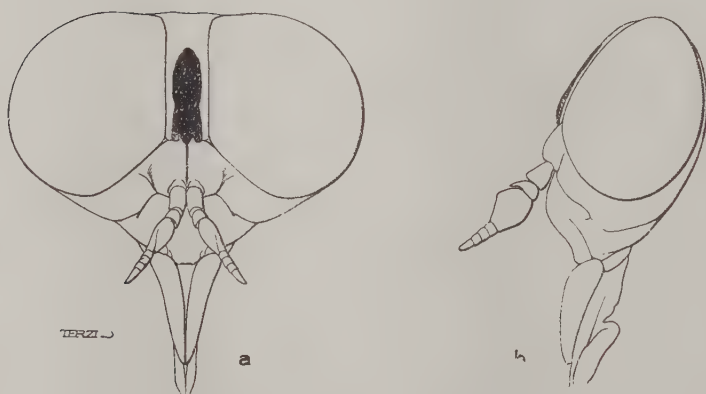


Fig. 6. *Tabanus insecutor*, Austen, ♀: a, head from in front ; b, head in profile, showing shape of antenna.  $\times$  10.

*Tabanus insecutor* is allied to *T. umbrinus*, Mg., with which it agrees in the character of the frontal callus of the ♀, the coloration of the eyes, and the shape of the terminal segment of the ♀ palpi; the new species may however be distinguished, *inter alia*, by the much greater development of the pale yellow hair

on the abdomen, particularly on the venter, and by the absence of the dark brown costal border on the wing, extending from the base of the wing to the end of the stigma, and of the broad dark brown blotch behind the latter.

#### 4. *Tabanus gigas*, Herbst.

Two ♂♂: one near Jerisheh, 5 miles N.-E. of Jaffa, 16.v.1918, hovering above low hill, 9.15 a.m. (one other specimen seen); the other in marsh 1 mile S.-E. of Tel Abu Zeitun (within 1½ mile of spot at which foregoing specimen was taken), 18.v.1918, on flower (one other example seen).

This strikingly handsome species, in which, as shown by the first of the two individuals recorded above, the eyes in life are purplish black, without bands, is already represented in the British Museum collection by, among other specimens, a ♂ from Galilee (*B. T. Lowne*, 1863-64). Statements by Brauer (*Denkschr. k. Akad. Wiss.*, Bd. xlii, 1880, p. 165) show that *Tabanus gigas* is found in France, Austria, Greece, Sicily, Russia, Syria and Asia Minor, while the series in the Museum includes specimens from Italy and Bulgaria.

In length, the two individuals taken by the writer measure respectively 19 and 18.5 mm.; their dimensions are therefore somewhat less than those given by Brauer (*loc. cit.*), according to whom the length of the ♂ is 20 mm., while that of the ♀ may be as much as 23 mm. The variability of *Tabanus gigas* as regards the coloration of the hairy covering of the head, body, and legs, according to the country of origin, is dealt with at some length by Loew (*Verh. z.-b. Ges. Wien*, Bd. viii, 1858, pp. 582-583), who refers to the species under its synonym *T. albipes*, Fabr. Although the two specimens recorded above as having been caught respectively on 16.v. and 18.v.1918 were captured within less than a mile and a half of each other, they nevertheless show considerable colour-differences of the kind indicated. While in the case of the ♂ taken in Tel Abu Zeitun marsh the pale hair on the head, thorax, tibiae and first two segments of the abdomen is of a rich ochreous tint, the corresponding hair in the case of the other specimen is much lighter in hue, and on the tibiae and the hind border of the second abdominal segment is even almost white. The individual with the paler hair also shows a median triangular patch of whitish hair on the hind border of the third abdominal tergite, and a smaller number of yellowish or ochreous hairs in the corresponding position on the following three tergites. These patches of pale hairs are entirely wanting in the other specimen, in which the paler fringe to the anal region is represented by but a very small number of ochreous hairs.

#### 5. *Tabanus mendicus*, Villen.

One ♀: Ain Sinia, 10 miles N. of Jerusalem, 18.iv.1918, on bank of stream, only specimen seen (*Captain K. B. Williamson, R.A.M.C.*).

In the living insect the eyes were bronze, with three horizontal, dark purple bands, the lowest the broadest, the middle one narrow.

The type of this somewhat unusual-looking species (a ♀, taken in the Oasis of Damascus, in the second fortnight in April) is not inaptly compared by Villeneuve (*Bull. Soc. Amis Sc. Nat. Rouen* (5) xlvii, 1912, pp. 41-42) to a tiny example of *Tabanus (Atylotus) gigas*, Herbst. The specimen from Ain

Sinia, recorded above, would seem to be only the second individual of *Tabanus mendicus* met with up to the present time. It is perhaps worth mentioning that, when viewed from the side, the insect appears to have a broad, shining, black band across the middle of the abdomen, owing to the third and fourth segments being clothed mainly with black hair, and thus contrasting with the base and distal extremity, on which the hairy covering is honey-yellow or cinnamon-buff, while the contrast is heightened by the ground-colour of the first two segments being neutral grey or olive grey pollinose.

#### 6. *Tabanus lunatus*, Fabr.

Jaffa district and Jerusalem: three ♀♀, near Mulebbis, 14.v.1918, caught by Lt.-Col. E. P. Sewell, C.M.G., D.S.O., R.A.M.C., from a light Ford motor-car (which the insects were following), at the same time and under the same circumstances as the type of *Tabanus insecutor*, Austen, see p. 298 (car proceeding at 20 miles an hour across a grassy plain; several specimens seen); a fourth ♀, in the British Museum collection, bearing the label "Jerusalem. A. Böttcher, Berlin," received in 1912 from the Zoologisches Museum, Berlin, and presented by Miss G. Ricardo.

The four specimens enumerated above, which are the only representatives of this small or medium-sized, greyish-olive-coloured, hairy-eyed species at present contained in the National Collection, show that, in the female sex at any rate, *Tabanus lunatus*, Fabr., is subject to considerable variation in size, the three examples brought home by the writer measuring from 10.75 to 11.75 mm. in length, as compared with 13.2 mm. in the case of the ♀ labelled "Jerusalem."

The eyes of the ♀ of *T. lunatus*, which are thickly clothed with short, fine, whitish hair, are bronze-green in life, with three narrow, purplish brown, transverse bands.

The description and figures of the head and palpus of the ♀ given by Brauer (*Denkschr. k. Akad. Wiss.*, Bd. xlii, 1880, p. 172, Taf. iii, figs. 34)—who records the species as occurring in Dalmatia, Italy, Sicily, Spain, Asia Minor and the Caucasus—are somewhat misleading, and since in the preceding synoptic table (*l. cit.*, p. 134) the upper frontal callus is characterised as "linear, connected with the lower callus . . ." it would be difficult if not impossible to determine female specimens of *T. lunatus* by means of the Austrian author's well-known work on "The European Species of the Genus *Tabanus*." A careful examination and comparison of the specimens brought back by the present writer shows that the upper frontal callus in the ♀ of *T. lunatus*, instead of being "elongate, more or less linear or fusiform" (Brauer), is roughly oval or elliptical oval in outline, and sometimes much larger than the lower callus, with which it is not connected; also that the terminal segment of the palpus in the same sex is acuminate, and only moderately swollen at the base—much less so than would be imagined from Brauer's description and figure. The sharp colour-contrast in the third joint of the antenna, owing to the expanded portion being cinnamon-rufous and the annulate portion dark seal-brown or black, is very noticeable.

#### 7. *Tabanus nemoralis*, Mg.

Two ♀♀, Mount of Olives, 20.iv.1918 (*E. E. A.*), and 4.v.1918 (*Captain (acting Lt.-Col.) W. J. Dale, O.B.E., R.A.V.C.*), both specimens taken "on ma 1."

In life, the eyes of the ♀ of this species are purplish bronze, with three dark purple horizontal bands, the middle one of which is the narrowest, across the centre.

*Tabanus nemoralis* is recorded by Brauer (*Denkschr. k. Akad. Wiss., Wien.*, Bd. xlii, pp. 175, 208-210 (1880)) as occurring in France, Switzerland, Italy, Sicily and North Africa: the British Museum collection contains specimens from Switzerland (Upper Engadine), and Algeria (Rouiba, May-June, 1911, *Baron J. R. M. Surcouf*).

#### 8. *Tabanus eggeri*, Schin.

One ♀, Wilhelma (Jaffa district), 30.vii.1918, resting inside small, open shed, at back of house in village: one ♀, near Jerisheh, 5 miles N.E. of Jaffa, 26. viii. 1918, in tent, 7.45 a.m. (*Lt.-Col. (temp. Col.) E. P. Sewell, C.M.G., D.S.O., R.A.M.C.*); one ♀, near Yahudiye (Jaffa district), i.ix.1918 (*Captain (acting Major) W. S. Corfield, R.A.M.C. (T.)*).

In this species, as was shown by the specimen taken near Jerisheh by Colonel Sewell, the eyes in life are purplish brown, with a bronze sheen, and are unbanded.

*Tabanus eggeri*, which is already represented in the British Museum collection, by, among others, specimens from Gibraltar, Italy and Algeria, is recorded by Brauer (*Denkschr. k. Akad. Wiss.*, Bd., xlii, 1880, p. 184—under the pre-occupied name *T. intermedius*, Egg.) as occurring in Southern France, Spain, Switzerland, Sicily, Corsica, Egypt and Asia Minor. As an aid to recognition it may be mentioned that, in the species under consideration, the diameter of the first posterior cell is greatly contracted on the hind margin of the wing. According to Brauer (*l. cit.*, p. 183), the hind tibiae are fringed on the outer side with black hair: the specimens from Palestine, however, show a slight variation from the typical form, in that the external fringe on the hind tibiae consists mainly of ochreous or ochraceous-tawny hair.

#### 9. *Tabanus autumnalis*, Linn.

One ♂, Baharet Katurieh, near El Jelil (about 10 miles N.E. of Jaffa), 28.iv.1918, only specimen seen; two ♀♀, Ain es-Sultan, near Jericho, 22.iv.1918—one taken on a horse, the other, as also a third specimen, which was not captured, resting on face of excavations.

This is a very widely distributed species, which, according to Brauer (*Denkschr. k. Akad. Wiss.*, Bd. xlii, 1880, p. 193), occurs throughout Central and Southern Europe, and is also found in Holland, Sweden, England, S. Russia, Poland, Corsica, Corfu, Syria and Asia Minor. Loew (*Verh. z.-b. Ges. Wien*, Bd. viii, 1858, p. 605), who draws attention to the variability of *T. autumnalis*, like that of so many other species, as regards both size and coloration, according to locality, records its range as including "the whole of Europe and a great part of the Near East." In addition to specimens from Hungary, Bulgaria, England and elsewhere, the species is represented in the British Museum (Natural History) by a ♀ from Algeria (Biskra, 18.v.1893, *Rev. A. E. Eaton*) and two ♀♀ from Cyprus (one collected by *P. Gennadius*, the second specimen taken by *Miss D. M. A. Bate*, near Ktima, between 3.v. and 15.vii.1901). It may be added that the three last-mentioned examples belong to the form of the species met with in Palestine, and also recorded by Loew (*loc. cit.*) as occurring in Cyprus, in which the ground-colour of the dorsum of the



abdomen in the ♀ is russet instead of black or blackish mouse grey, while the venter in the same sex is pale smoke grey pollinose orange-cinnamon or pinkish cinnamon, and the usual broad, dark, median longitudinal ventral stripe is absent or but faintly indicated in both sexes. Two other Algerian ♀♀ of this species (taken respectively at Algiers and Hammam R'irha, in May 1908, by the *Hon. W.* (now *Lord*) *Rothschild*), in the National Collection, belong to the typical form.

Loew (*loc. cit.*) remarks that South European examples of *Tabanus autumnalis* are on the whole decidedly smaller than specimens from Germany and Northern Europe. The respective lengths of the three individuals from Palestine, recorded above, are 15.75, 15, and 19.5 mm.; thus it will be seen that, as compared for instance with English representatives of the species under discussion, the two former are markedly subnormal in size.

#### 10. *Tabanus regularis*, Jaenn.

One ♀, in Wadi el Kelt, Jericho Plain, 1.vi.1918. The eyes of this specimen in life were dark purplish brown, without bands.

*Tabanus regularis*, which was described from a specimen from S. France (Marseilles district), and is included by Brauer among the Tabanidae of Italy and Greece, has recently been recorded by Becker (*Ann. Mus. Zool. Acad. Imp. St. Pétersbourg*, xvii, 1912, p. 596) as occurring in Persian Baluchistan.

#### 11. *Tabanus rupinae*, sp. n. (figs. 7, 8).

♂♀.—Length, ♂ (2 specimens) 14.5 to 15.4 mm., ♀ (3 specimens) 15 to 16.2 mm.; width of head, ♂ 5.4 to 5.6 mm., ♀ 5.2 to 5.6 mm.; width of front of ♀ at vertex 0.75 to 0.8 mm.; length of wing, ♂ 11.25 to 12 mm., ♀ 12.6 to 13.25 mm.

*Dorsum of thorax light greyish olive (deep greyish olive when rubbed) pollinose, clothed with fine, silky, appressed as well as erect, ochreous hair, mingled with fine, erect, blackish hairs, the erect ochreous hair whitish at the tips; dorsum of abdomen ochraceous-tawny, with a pale, median longitudinal stripe running from base of second to hind margin of penultimate tergite; anterior branch of third longitudinal vein abruptly angulate at the base, and provided with a long appendix; front femora dark mouse-grey (smoke-grey pollinose on outer side), front tarsi and distal halves of front tibiae black.*

*Head*: face and jowls pale olive-grey in both sexes, clothed with whitish hair; occiput pale olive-grey in ♂, smoke-grey or pale smoke grey in ♀, hind margin of occiput in region of vertex clothed with very short whitish or pale yellowish hair; frontal triangle in ♂ smoke grey or pale smoke-grey pollinose; *front* in ♀ olive-buff pollinose, moderately broad and of practically uniform width, its length equal to about four and a half times its breadth between inner angles of eyes, clothed with short, appressed, ochreous hairs, mingled in region of vertex with minute blackish hairs; lower *frontal callus* in ♀ blackish brown or sepia-coloured, transversely oblong, its depth equal to about three-fourths of its breadth, narrowly separated from eye on each side, its lower margin situate just above level of inner angles of eyes; upper frontal callus in ♀ represented by a somewhat ill-defined, dark brown, crescentic mark, with long horns extending upwards, but its precise

shape evidently dependent upon degree of rubbing to which the specimen has been subjected; ocellar tubercle in ♂ very small and inconspicuous, situate at bottom of cleft between eyes at vertex, no trace of ocellar tubercle in ♀; subcallus in ♀ pinkish buff pollinose, with a more or less distinct indication of a tawny-olive or light mummy-brown transverse band extending from eye to eye at level of antennae; eyes under an ordinary hand-lens appearing bare in both sexes (closer scrutiny sometimes reveals scattered minute hairs on lower portions), eyes in ♂ each with a bluntly triangular area of greatly and abruptly enlarged facets, partly encircled with a sharply contrasted zone of small facets occupying approximately lower fourth and outer and upper border, latter being continued to vertex in practically its full width; eyes of ♀ in life dark green, with purplish-brown sheen and without bands; palpi of ♂ clothed with whitish hair, terminal segment cream-coloured, greatly swollen, ovate pyriform and ending in a small curved point, proximal segment of ♀ palpi clothed with fairly long, whitish hair, terminal segment of ♀ palpi long

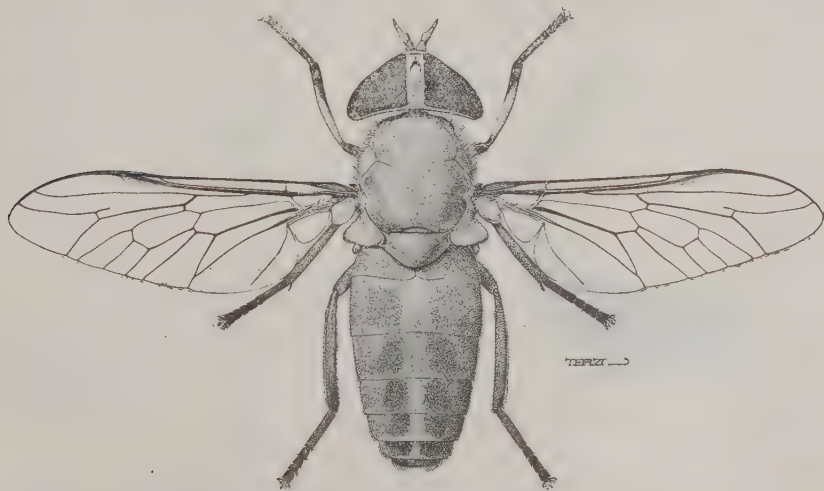


Fig. 7. *Tabanus rupinae*, Austen, ♀.  $\times 4$ .

acuminate, considerably swollen at base, cream-coloured or ivory-yellow, clothed on outer side with short, appressed, glistening hair of similar colour (occasionally intermixed with a few minute black hairs towards distal extremity), and with longer whitish hair at base below; first joint of antennae cinnamon-buff, cream-buff pollinose, clothed with minute, appressed, glistening yellowish or whitish hair, with longer pale hair below, and with minute black hairs on upper distal angle, considerably swollen and expanded distally and partly embracing second joint, latter agreeing with first joint in coloration and in its hairy covering and with its upper distal angle considerably produced, third joint cinnamon, annulate portion infuscated at tip, at least in dried specimens, expanded portion narrow and elongate in ♂, of considerable depth in ♀, with a prominent but blunt angle near base of upper margin in both cases. Thorax: anterior border of dorsum in certain specimens showing more or less distinct vestiges of three pallid neutral grey

longitudinal stripes; swelling in depression at each end of transverse suture drab-grey or light drab; pleurae and pectus pale smoke-grey, clothed with whitish hair. *Abdomen*: pale, median, longitudinal stripe on dorsum sometimes, especially in ♂, formed by a linear series of anteriorly directed, truncated triangles; median stripe, at least on third (visible) and following tergites, bordered on each side with a dusky, oblong blotch, extending for the full length of the segment except extreme hind border, and clothed with minute, appressed, black hairs (like rest of hairy covering of dorsum very easily removed by rubbing, in which case the blotches are difficult to distinguish); on each side of third and two following tergites, outside dusky blotch just described, a more or less distinct trace of another pale stripe or oblique pale mark, sometimes bordered on outer side on fourth and fifth tergites, at least in case of ♂, with another dusky, black-haired blotch, not reaching hind margin; sixth and seventh tergites, except lateral and hind borders of former and its median stripe, dark brown and clothed with minute, appressed, black hairs (posterior angles of sixth tergite in ♂, and hind border of seventh in both sexes

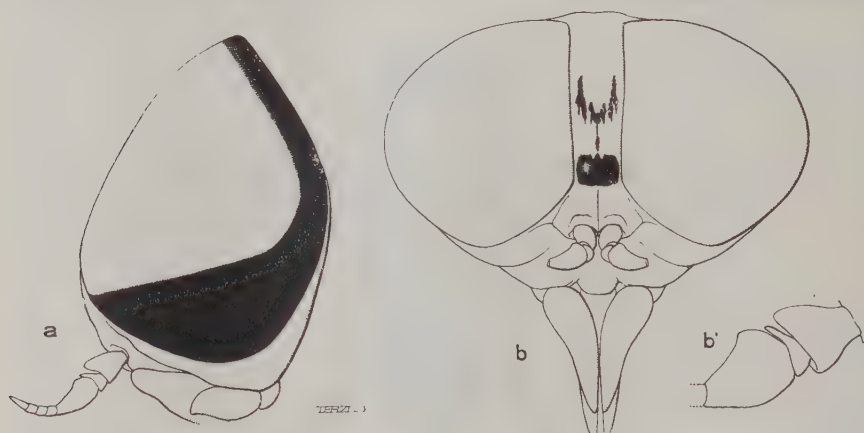


Fig. 8. *Tabanus rupinae*, Austen: a, head of ♂ in profile; b, head of ♀ from in front,  $\times 10$ ; b', antenna of ♀ from the side, greatly enlarged.

clothed with longer black hair); dorsum, except as already stated, clothed with minute, appressed, glistening, ochreous hairs, longer and paler on hind borders of segments, extreme lateral borders of tergites pale drab-grey pollinose and clothed with longer whitish hair; ventral scute of first (visible) segment pale drab-grey pollinose, remainder of venter except terminal segment pale cinnamon or pinkish cinnamon, covered with cream-buff pollen and clothed with whitish or appressed, glistening, pale yellowish or pale ochreous hair, hind borders of segments cream-buff or pale drab-grey pollinose, clothed with longer pale hair; ventral surface of terminal segment mouse-grey or deep mouse-grey, clothed as usual with coarse, erect, black hair, in case of ♂ sometimes a few similar hairs on ventral surface of preceding segment also. *Wings* suffused with light drab; *stigma* inconspicuous, elongate, pale tawny-olive; veins lighter or darker sepia-coloured. *Squamae* cream-buff, borders cinnamon-buff. *Halleres* cream-buff or cream-coloured, knobs

sometimes darker (seal-brown or light seal-brown) at base. *Legs*: coxae pale drab-grey or smoke-grey pollinose, clothed with whitish hair; femora and tibiae of middle and hind legs, and proximal halves or rather less than proximal halves of front tibiae, cinnamon-buff or pinkish cinnamon-coloured, middle and hind femora drab-grey pollinose; middle and hind tarsi dark brown above, first joint of middle tarsi sometimes paler towards base; third and fourth joints of middle and hind tarsi distinctly expanded, rather broad; femora clothed with whitish hair; middle and hind tibiae and proximal halves of front tibiae clothed with short, glistening, appressed yellowish-white hair, which on anterior margin of outer side of hind tibiae is elongated so as to form a fringe; upper surfaces of tarsi and distal halves of front tibiae clothed with minute black hairs, extensor surfaces of middle and hind tibiae, especially towards tips, also largely clothed with similar hairs.

Wadi el Kelt, Jordan Valley, near Jericho: type of ♂ and one para-type of the same sex, 5.vi.1918, on cliff wall, 5.30 p.m.; type of ♀ and one ♀ para-type 1.vi.1918; an additional ♀ para-type 25.v.1918, resting on the author's tent (pitched above the Wadi, close to the point at which the old Jerusalem-Jericho road enters the Valley), 6.30 a.m.

On several evenings at the beginning of June 1918, towards sunset, a number of specimens of this species, which was not met with elsewhere, were found resting on the precipitous earth cliffs forming the sides of the Wadi el Kelt, just where the wild gorge in question leaves the hills.

*Tabanus rupinae*, which is not closely allied to any of its congeners known to the writer, presents a very slight superficial resemblance to the Mesopotamian *T. polygonus*, Walk., but is distinguishable at once, *inter alia*, by the somewhat wider front in the ♀; by the lower frontal callus in the same sex being transversely quadrate, instead of vertically ogival and prolonged above into a narrow line; by the second abdominal tergite in both sexes being without any trace of a blackish median spot at the base; by the anterior branch of the third longitudinal vein being abruptly angulate at the base and provided with a long appendix; and by the very different coloration of the front legs.

## 12. *Tabanus arenivagus*, sp. n. (figs. 9, 10).

♂♀.—Length, ♂ (3 specimens) 13.5 to 14 mm.; ♀ (10 specimens) 12 to just over 14 mm.; width of head, ♂ 4.5 to 4.75 mm., ♀ 3.6 to 4.4 mm.; width of front of ♀, at vertex 0.5 to 0.75 mm., between inner angles of eyes 0.4 to 0.5 mm.; length of wing, ♂ 10.5 to 11 mm.; ♀ 10 to 11.2 mm.

*Small, light drab-coloured, narrow-bodied species, with sides of abdomen straight, tapering from base of fifth segment in ♂, and from that of second segment in ♀; eyes under an ordinary hand-lens appearing bare (merely showing sparse microscopic hairs below), in ♂ with a sharply contrasted area of greatly enlarged facets, and two purplish-brown transverse bands, in ♀ with three similarly coloured bands: frontal triangle in ♂ and subcallus in ♀ with a shining transverse band, extending from eye to eye; ♂ with well-developed though sunken ocellar tubercle, of which there is no trace in ♀; latter with two frontal calli; third joint of antennae ochraceous-buff or ochraceous-orange, narrow, elongate and tapering, its upper margin not excavated but with a blunt*



angle near base ; dorsum of abdomen with four longitudinal rows of oblique, elongate, mummy-brown markings, more distinct in ♀ ; wings hyaline, stigma brownish olive, elongate and distinct, anterior branch of third vein without an appendix.

Head conspicuously enlarged in ♂ ; face and jowls in both sexes whitish pollinose and clothed with whitish hair, a faint, not always distinguishable infuscation between base of each antenna and corresponding eye ; occiput pallid neutral grey pollinose, its upper margin fringed behind with erect, pale yellowish hair, very short in ♀, longer and somewhat curved forward in ♂, frontal triangle in ♂ and front and sub-callus in ♀ pale smoke grey or smoke grey pollinose, front in ♀ clothed with minute, appressed, pale ochreous hairs, and its ground-colour somewhat darker (mouse grey) in vertical region ; shining transverse band on frontal triangle in ♂ nearly twice as deep as corresponding band on subcallus in ♀ and much darker (clove brown), its upper margin level with upper border of area of small facets forming rather less than lower third of eyes, and its lower



Fig. 9. *Tabanus arenivagus*, Austen, ♀. × 4.

margin separated from base of antennae by a space equal to about half the depth of the band ; corresponding band in ♀ brownish olive or isabella-coloured, and occupying rather more than upper half of subcallus ; front in ♀ of medium width, distinctly narrower below, neither callus in contact with eyes, lower callus quadrate, shining, light sepia-coloured and situate well above inner angles of eyes, upper callus much larger and darker (seal brown or dark brown) than lower, not shining, quadrate, situate just below midway between vertex and lower callus, with which it is not connected, and generally with a more or less distinct longitudinal groove or depression in middle line ; area of enlarged facets in eye of ♂ sharply defined, bluntly triangular in outline, and occupying rather more than upper two-thirds, with exception of a narrow hind border of uniform width ; eyes of ♂ in life with area of enlarged facets pinkish isabella-coloured above, light grey on lower border ; area of small facets with hind border dark brown, with greenish reflections, lower border greenish-bronze, with two narrow, purplish-brown,

transverse bands, extending to hind margin, and, below these, a very fine, and shorter darkish, horizontal, transverse streak; *eyes of ♀ in life* greenish-bronze, with three horizontal, purplish-brown bands, and a very narrow dark streak above and below; *palpi* pale cream-buff, those of ♂ and proximal joint of those of ♀ clothed with long whitish hair, distal joint of ♀ palpi clothed on outer surface with glistening, appressed, pale yellowish hairs mixed with minute, appressed, black hairs, and bearing longer pale yellowish or whitish hairs on under surface; distal joint of ♂ palpi elongate ovate or ovate pyriform, corresponding joint in ♀ curved, tapering, pointed at tip, not greatly swollen at base; first and second joints of *antennae* cinnamon-buff, clothed on outer side with pale yellowish hair, and on distal margin of second joint and upper distal angle of first joint with minute black hairs, first joint somewhat greyish pollinose, moderately swollen in ♂, upper distal angle of second joint not produced, annulate portion of third joint straight. *Thorax*: dorsum with four dark mouse-grey or fuscous longitudinal stripes, separated by narrower drab-grey or pale drab-grey interspaces, lateral borders pale drab-grey or pale smoke-grey—swelling occupying depression at each end of transverse suture pale brownish drab; dorsum of ♂ clothed with fine, erect, pale yellowish or whitish hair, mixed with short, glistening ochreous, appressed hairs, and sometimes also interspersed with darker erect hairs, post-alar calli and swelling immediately above base of each wing in ♂ clothed with whitish hair; dorsum of ♀ clothed with short, appressed, glistening pale yellowish or ochreous hair, mixed with a certain number of short and more erect blackish hairs, hair on postalar calli and on swelling above base of wing on each side as in ♂; pleurae and pectus in both sexes pale smoke-grey, clothed with whitish hair. *Abdomen*: pattern of markings on dorsum as shown in fig. 9, mummy-brown markings on second (visible) and following segments starting from base of segment but not reaching hind border, so that on each segment the drab-coloured markings, consisting of a median triangle and an oblique elliptical ovate spot between latter and each lateral margin, are as a rule connected together posteriorly; on fifth and sixth segments, however, mummy-brown markings on each side are often themselves connected together in each case, in such a way as to enclose the drab-coloured ovate spot; lateral margins of dorsum pale smoke-grey; dorsum clothed with minute, appressed, shining pale yellowish hair (in case of ♀, with minute, appressed black hairs on the dark markings), lateral margins in ♂ clothed with longer whitish hair, seventh segment in ♀ and sides of fifth, sixth and seventh segments in ♂ with longer blackish hairs; venter drab-grey (hind borders of segments cream-buff), clothed with short, appressed, pale yellowish hair, seventh segment also with the usual relatively coarse, erect, black hair. *Wings*: veins pale sepia-coloured, here and there, especially anterior transverse vein and base of anterior branch of third vein, distinctly darker. *Squamae* smoke-grey, borders paler. *Halteres*: knobs seal-brown (cream-buff at extreme tips), stalks cream-buff. *Legs*: light buff, femora greyish pollinose, front pair sometimes streaked with mouse-grey above or on outer side, tips of tibiae and upper surface of middle and hind tarsi (at least distal extremities of joints of latter) sepia-coloured, front tarsi clove brown (first joint in ♀ sometimes paler except at tip), slightly expanded in both sexes, third and fourth joints of middle tarsi in ♂ also somewhat expanded; femora clothed with whitish hair, long and fine in case of ♂; tibiae clothed with

glistening pale yellowish hair, which on outer side of hind pair forms an outstanding fringe (longer in ♂), which is usually mixed with black hairs; tips of tibiae and upper surface of tarsi clothed with minute black hairs, similar hairs also present to a varying extent on outer surface of tibiae, above tips.

S. Palestine: El Fukhari (8 miles W. of El Shellal, Wadi Ghuzze) and vicinity, September-October, 1917. Type of ♂, El Fukhari, 21.ix.1917 (*Lt.-Col. P. S. Lelean, C.B., C.M.G., R.A.M.C.*); type of ♀, same locality, 27.ix.1917 (entered author's tent at dusk, attracted by lamp); eleven para-types as follows:—1 ♂, near Wadi Ghuzze, 25.ix.1917 (*Lt.-Col. E. P. Sewell, C.M.G., D.S.O., R.A.M.C.*); 1 ♂, El Fukhari, 4.x.1917 (*Col. J. A. Stewart, R.A.O.C.*); 8 ♀♀, El Fukhari, 16.ix.-7.x. 1917; 1 ♀, Weli Sheikh Nuran, 22.ix.1917 (*Lt.-Col. Arnold, A.A.M.C.*).

*Tabanus arenivagus*, which was not met with outside the Fukhari area, was fairly common during the latter half of September and early part of October, 1917, in XXth Corps Headquarters Camp at El Fukhari, where it was the only *Tabanus* seen. The spot, though sparsely dotted with low scrub, was a perfectly dry, sandy

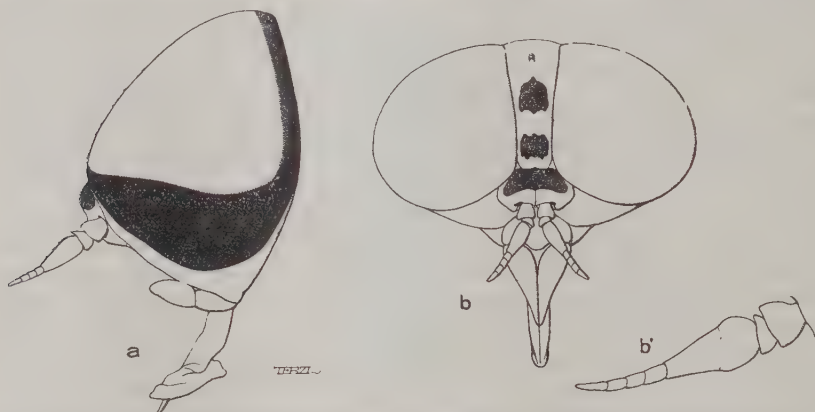


Fig. 10. *Tabanus arenivagus*, Austen: a, head of ♂ in profile; b, head of ♀ from in front,  $\times 10$ ; b', antenna of ♀ from the side, greatly enlarged.

one, entirely waterless, on the edge of a desert region, and there was no obvious breeding-place whence the flies could have come, nearer than an occasional damp hollow among the sand-dunes near the coast, several miles further west. The author twice took ♀♀ inside his tent at dusk, and at the same time on 22.ix.1917 was bitten on the hand by a third specimen in the open; on another occasion (26.ix.1917) an officer was attacked by one of these flies, while sitting inside a mess-shelter constructed of reed matting.

In size, general appearance, general coloration, and in the pattern of its abdominal markings, *Tabanus arenivagus* somewhat resembles *T. pulverifer*, Walk., the typical series of which was obtained at Baghdad. The species described above, however, is distinguished from *T. pulverifer*, *inter alia*, by the presence of a shining band on the frontal triangle of the ♂ and subcallus of the ♀; by the lower frontal callus in the ♀ being paler, and usually smaller and less sharply defined; by the presence in the ♀ of a relatively large, well-marked, subquadrate



upper (median) frontal callus, instead of the ill-defined transverse band, which represents it in the case of *T. pulverifer*; by the distal segment of the palpi in both sexes being narrower (less sharply pointed in the ♀) and deeper in tint, and in the case of the ♀ bearing many black hairs on the outer surface; by the first joint of the antennae in both sexes being smaller, and the third joint paler, narrower, and much more elongate; by the wing-stigma being more sharply defined, and by there being no trace of an appendix to the anterior branch of the third vein.

*Tabanus arenivagus* likewise resembles an undetermined species represented in the British Museum collection by a solitary ♀ from Arabia (Muscat), but is distinguished by the front in the ♀ being more distinctly narrower below (the inner margins of the eyes being convergent); by the upper portion of the subcallus in the ♀ being shining, and the lower frontal callus much smaller, and not reaching the inner angles of the eyes; by the smaller size (less prominent upper angle) of the first joint of the antennae; by the dorsum of the abdomen having a longitudinal series of pale triangles in the median line, instead of a broad, pale, longitudinal stripe of more or less uniform width; and by the stigma of the wing being more distinctly marked.

### 13. *Tabanus accensus*, sp. n. (figs. 11, 12).

♀.—Length (3 specimens) 12 to 13.4 mm.; width of head 3.8 to 4.25 mm.; width of front at vertex just under 0.6 to 0.6 mm.; length of wing 9 to 9.75 mm.

*Small, greyish species, with two frontal calli in ♀; bare eyes; dorsum of thorax neutral grey or deep neutral grey, longitudinally striped with pale olive-grey; somewhat narrow straight-sided abdomen, smoke-grey or pale pinkish buff above, with four longitudinal series of elongate blackish brown marks, lateral borders of segments pale smoke-grey pollinose, hind borders of second and following segments cream-buff; and parti-coloured legs.*

*Head:* front in ♀ smoke-grey pollinose, subcallus pale pinkish-buff pollinose, front clothed with short, pale yellowish or bright ochreous appressed hair, in region of vertex sometimes also with short blackish or dusky hair, no trace of an ocellar tubercle but a tiny, dusky, mouse grey or deep mouse grey spot in middle line in region of vertex; face and jowls greyish white pollinose, clothed with whitish hair; occiput pale smoke-grey pollinose, hind margin fringed above with very short and inconspicuous whitish or yellowish white hair; *front* in ♀ of moderate breadth or relatively somewhat broad, slightly but distinctly narrower below, about four times as long as its breadth at the lower end; *lower frontal callus* shining blackish brown, large, quadrate and nearly square, extending from eye to eye or separated from eye on each side by narrowest possible pollinose interval, lower margin convex and descending slightly below level of inner angles of eyes, upper edge with two small emarginations and consequently produced into three points, upper frontal callus black or blackish brown, oval or elliptical oval, not connected with lower; *eyes of ♀ in life* with upper angles and lower borders dark purplish brown, and central portion metallic bronze or bronze-green, crossed by two narrow, deep blue, horizontal bands; *palpi* ivory-yellow or cream-coloured, proximal segment clothed with long whitish hair, distal segment in ♀ acuminate, moderately or considerably swollen at base, clothed on outer side with minute, appressed,



glistening whitish hairs, mixed with minute black hairs; first joint of *antennae* light drab or light pinkish cinnamon pollinose, moderately swollen towards distal extremity, with upper distal angle considerably produced and partly embracing second joint, clothed on outer side with glistening yellowish hairs and with minute black hairs on upper border and towards upper distal angle, second joint of antennae light drab pollinose, with distal margin fringed on outer side below with minute glistening yellowish hairs and upper distal angle moderately or considerably produced, third joint cinnamon- or orange-cinnamon-coloured (annulate portion sometimes darker, dark brown or blackish brown), expanded portion of moderate depth or rather narrow, with blunt but prominent angle on upper margin near base. *Thorax*: dorsum clothed with minute, appressed, yellowish or whitish, silky hairs, yellowish tinge in the hair being more apparent in interspace between posterior ends of the two admedian pale olive-grey pollinose stripes (median pale olive-grey stripe becoming obsolete at about level of transverse suture); lateral borders of dorsum pallid neutral grey or pale smoke grey pollinose, swelling in



Fig. 11. *Tabanus accensus*, Austen, ♀.  $\times 4$ .

depression at each end of transverse suture drab-grey, clothed below with long, dusky or blackish hair, and above with shorter yellowish hair; pleurae and pectus pale smoke grey pollinose, clothed with whitish hair. *Abdomen*: middle line of dorsum, from first (visible) to sixth segments inclusive, occupied by a longitudinal series of anteriorly directed, truncated, smoke grey or pale pinkish buff triangles: blackish brown marks, except in some specimens admedian ones on first tergite, not reaching hind borders of segments; in some cases, on each segment from third or fourth to sixth inclusive, the ends of each pair of blackish brown marks are fused together posteriorly in such a way as to enclose intervening smoke grey or pale pinkish buff area, which then assumes appearance of an elliptical oval, more or less oblique spot: pale areas of dorsum, including hind borders of second to sixth tergites inclusive, clothed with minute, appressed, glistening, pale yellowish or pale ochreous hairs, blackish brown areas clothed with minute, appressed, black or blackish hairs; seventh tergite, except lateral and hind borders, dark brown, smoke grey pollinose at base, clothed with fine, fairly long, curving, black or blackish

hair; venter pale smoke grey or pale drab-grey pollinose, clothed with minute, appressed, glistening, ivory yellow hairs, hind borders of second to sixth scutes inclusive ivory yellow, seventh segment deep greyish olive or mouse grey pollinose, clothed with usual coarse, erect, blackish hair. *Wings*: clear, hyaline, veins lighter or darker olive-brown, anterior branch of third longitudinal vein without an appendix, at least in typical form; *stigma* pale isabella-coloured or almost colourless, inconspicuous. *Squamæ* ivory yellow, borders cream-buff. *Halteres*: knobs ivory yellow, stalks pale cream-buff. *Legs*: coxae smoke grey or pale smoke grey pollinose, clothed with whitish hair; femora, except tips which are cream-buff, light greyish olive or smoke grey pollinose, clothed with whitish hair (extreme tips, at least of front and middle femora, with minute black hairs above), inner and under sides of front femora blackish brown or warm sepia-coloured, inner sides more or less smoke grey pollinose: tibiae cream-buff, tips (distal sixth in case of middle and hind pairs, distal fourth or rather less in case of front pair) blackish brown or dove brown, pale area of tibiae clothed with minute, appressed, glistening ivory yellow hairs, mingled on extensor surfaces with minute black hairs; front

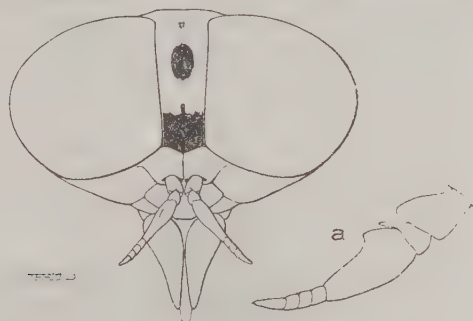


Fig. 12. *Tabanus accensus*, Austen, head of ♀ from in front,  $\times 10$ ; a, antenna from the side, greatly enlarged.

tarsi blackish brown, first joint more or less clothed above, except at distal extremity, with minute appressed, glistening ivory yellow hairs; middle and hind tarsi clove brown, proximal two-thirds or three-fourths of first joints cream-buff or cream-coloured, clothed with minute, appressed, glistening ivory yellow hairs, mingled with minute black hairs.

Lower Jordan Valley and Jerusalem: type from Wadi el Kelt, Jericho Plain 11.vi.1918, biting author's arm; a para-type from Wadi Mellaha (about  $6\frac{1}{2}$  miles N.E. of Jericho, near R. Jordan), 26.v.1918, on horse; a third specimen labelled "Jerusalem," received in 1912 from the Zoologisches Museum, Berlin.

In size as well as in thoracic and abdominal markings *Tabanus accensus*, at least in the female sex, presents a distinct resemblance to the Ethiopian *T. pertinens*, Austen; the female of the new species is, however, at once distinguishable, *inter alia*, by the much narrower front, by the presence of two black or blackish brown frontal calli instead of the single callus being either absent or scarcely noticeable, and by the very different coloration and markings of the legs, especially the tibiae and tarsi.

14. *Tabanus leleani*, sp. n. (figs. 13, 14.)

♂♀.—Length, ♂ (8 specimens) 12 to 14 mm., ♀ (17 specimens) 11 to 14.6 mm.; width of head, ♂ 4.4 to 5.4 mm., ♀ 4.25 to 5.4 mm.; width of front of ♀, at vertex 0.8 to 1 mm., across lower edge of frontal callus 0.5 to 0.75 mm.; length of wing, ♂ 8.75 to 10.8 mm., ♀ 8.75 to 11.6 mm.

In general appearance looking like a greyish form of *Tabanus cordiger*, Mg., with which it closely agrees as regards pattern of abdominal markings, and dimensions and other details of ♀ front. Eyes under an ordinary hand-lens appearing bare in both sexes, in ♂ with a sharply contrasted area of greatly enlarged facets, and in both sexes with a single, horizontal, transverse band; dorsum of thorax (in undamaged specimens) mouse grey, clothed with fine erect hair, interspersed with a coating of fine, appressed, short, silky hair, of an ochreous or somewhat paler colour; dorsum of abdomen dark mouse grey or blackish mouse grey (when viewed at a low angle from behind suffused, like thorax, with pale neutral grey bloom), with, in middle line, a longitudinal series of pallid neutral grey triangles, and, on each side, midway between middle line and lateral margin, a series of oblique and roughly elliptical spots of same colour, sides of two or more of the proximal segments, from posterior angles of first (visible) to fourth inclusive, often more or less cinnamon; wings hyaline, stigma scarcely distinguishable, anterior branch of third vein typically without appendix.



Fig. 13. *Tabanus leleani*, Austen, ♀. × 4.

Head: face and jowls whitish pollinose and clothed with white hair, occiput in both sexes, frontal triangle in ♂, and front and subcallus in ♀ pale olive-grey pollinose; frontal triangle in ♂, immediately below level of enlarged facets of eyes, crossed by a somewhat deep, dusky, shimmering pollinose, horizontal band; in both sexes a dark clove-brown horizontal band between base of antenna and eye on each side; hind margin of upper border of occiput fringed with short, erect or forward-curving, whitish or pale yellowish hair, among which are occasionally intermixed on each side a few short black hairs, though, at least in the case of the ♂, the fringe is much shorter than the corresponding one in *T. cordiger*, Mg.; front

in ♀ broad, slightly narrower below, its length equal to rather less than four times its breadth at lower margin of lower callus, clothed above with minute black hairs and below with appressed yellowish hairs, vertex darker (dark olive-grey), but without trace of ocellar tubercle; two *frontal calli* in ♀, lower frontal callus shining black or blackish-brown, large, broad, quadrate, about four-fifths as high as broad, only separated from eye on each side by an exceedingly narrow, pollinose interval; upper frontal callus in ♀ represented by a large black mark, rather less than half-way between upper margin of lower callus and vertex, separated from eye on each side, bare of pollen but in undamaged specimens clothed with minute, appressed, yellowish hairs, and usually either roughly V-shaped, or transversely oval or elliptical, with a deep, narrow indentation in middle line above; *eyes* in ♂ with sharply defined hind and upper border of small facets, not tapering off but extending in full depth to vertex, while greatest depth of lower border, which also consists of minute facets, is about  $2\frac{1}{2}$  times that of upper border; *eyes of ♂ in life* with area of large facets greyish brown or a beautiful steely grey, lower border consisting of small facets purplish bronze or reddish brown, a dark horizontal band, coloured like the band in ♀, close to upper margin of lower border, hind and upper border dark purplish brown; *eyes of ♀ in life* bronze-green with a purplish sheen, or purplish bronze, with a single, horizontal, dark purple, dark purplish brown, or dark brown band, starting from inner margin of each eye adjacent to lower frontal callus, extending outwards and backwards, and ending bluntly at about one-fifth of the diameter from hind margin; *palpi* light buff, or ivory white (proximal segment mouse grey at base), clothed with whitish hair, in case of ♂ usually mingled towards distal extremity of greatly swollen, pyriform or ovate pyriform, terminal segment with a few minute black hairs; terminal segment of ♀ palpi acuminate (proximal half greatly swollen), its outer surface clothed with minute, appressed, glistening white or yellowish white hairs, frequently mixed with minute, scattered, appressed, black hairs; first and second joints of *antennae* blackish (first joint somewhat greyish pollinose above), clothed below with glistening whitish hair and above with minute black hairs, first joint greatly swollen, its bluntly produced upper distal angle overlapping the sharp corresponding angle of the small second joint, third joint warm sepia-coloured to fuscous-black, its expanded portion moderately broad, with a blunt but fairly prominent angle close to base of upper margin. *Thorax*: dorsum with usual light grey longitudinal stripes more or less distinctly marked, erect hair partly blackish, partly pale (light buff), except on anterior margin, where it is entirely whitish; swelling in depression at each end of transverse suture greyish pollinose vinaceous-fawn, clothed mainly with black hair; humeral and postalar calli, and lateral border of dorsum above base of wing on each side, clothed with whitish hair; pleurae and pectus pallid neutral grey pollinose, clothed with fairly long, fine hair of same tint. *Abdomen*: lateral margins of tergites, from second or third (visible) to distal extremity, and posterior borders of dorsal and ventral scutes of all segments cream-buff; basal angles of first (visible) tergite more or less greyish pollinose; pallid neutral grey markings of dorsum, described in diagnosis above, clothed with minute, appressed, cream-coloured hairs, and usually most distinct (sharply defined in ♀) on second and three following segments, but sometimes distinguishable on first and sixth segments



also; in the case of the second to fifth segments inclusive the median triangles, which are based on the hind margins and taper sharply forwards, reach the anterior margins, while in the ♀ the oblique spots sometimes similarly extend over the full length of the segments; dark areas of dorsum clothed with minute black hairs—towards lateral margins of fifth and following segments in ♂, and on sixth and seventh segments in ♀, the hair is longer; lateral margins of all segments from second to sixth inclusive clothed with fairly long whitish hair; venter pallid neutral grey pollinose, clothed, except in case of last (visible) segment, which is bedecked with the usual coarse, outstanding black hairs, with minute, appressed, glistening, creamy-white hairs, a certain number of black hairs on penultimate segment also, on median area in front of hind margin. *Wings*: veins dark clove-brown, except basal portions of second and fifth longitudinal veins, which are paler (sepia-coloured): *stigma* when discernible, pale cinnamon, narrow. *Squamae* cream-buff, borders darker (isabella-coloured). *Halteres* ivory yellow, stalks somewhat infuscated, and knobs usually seal-brown at base above and below. *Legs*: coxae and femora (except extreme tips of latter, which are cinnamon-buff, and inner and under sides of front femora, which are black—sometimes greyish pollinose in case of inner side) pale neutral grey pollinose, clothed with whitish hair; front tibiae black, their proximal halves, or rather more or rather less, cinnamon-buff or pale pinkish buff, and clothed with minute, appressed, whitish hairs, which may extend on to the black area, outer surface of front tibiae also with longer hairs, some whitish others black, or whitish on proximal half and black towards distal extremity; middle and hind tibiae, except extreme tips, which are tinged with seal brown, cinnamon-buff, clothed with whitish hair, which is long (relatively dense also in the case of the ♂) on outer side of hind pair; it is also long on outer side of middle tibiae, where however it is sparse and intermixed with scattered black hairs (likewise sometimes present on outer side of hind tibiae); front tarsi black, not expanded, hind tarsi and upper surface of middle tarsi seal brown or dark brown, under surface of middle tarsi, as also upper surface of fifth joint and of proximal two-thirds of first joint, cinnamon.

Type of ♂ in Wadi el Kelt, Jordan Valley, near Jericho, 1.vi.1918; type of ♀, and three para-types of the same sex in Wadi el Aujah (6½ miles north of Jericho), Jordan Valley, 19.iv.1918; additional para-types as follows:—3 ♂♂, (1 resting on rocky bank above pool) 3 ♀♀, in Wadi Ghuzze, near Tel el Fara, 5.vi., 4-23.vii., and 8.viii.1917; 3 ♀♀, Ain es-Sultan, near Jericho, 22.iv.1918; 3 ♂♂ (resting on cliff wall, 5.30 p.m.), 1 ♀ (tried to bite author, 10.30 a.m.), in Wadi el Kelt, near Jericho, 3-5.vi.1918; 1 ♀, Wadi ez Zerka, 5.viii.1918 (*Captain (acting Lt.-Col.) W. J. Dale, O.B.E., R.A.V.C.*), on horse.

As throwing light on the range of this species, it may be noted that in addition to the foregoing, the Museum also possesses the following specimens of *T. leleani*:—1 ♂ (*ex coll. Saunders*), 1 ♀ (1909, *Dr. G.A. Williamson*), from Cyprus; 1 ♀, Sbeitla, Tunis, 6.v.1913 (*G. C. Champion*); 2 ♀♀, Biskra, Algeria, 14.iv.1894, 31.v.1893 (*Rev. A. E. Eaton*), and 1 ♀ from same locality, 1908 (*Hon. W.—now Lord—Rothschild*); 1 ♀, Nasiryah, R. Euphrates, Mesopotamia, April-June 1916 (*Major W. S. Patton, I.M.S.*); and 1 ♀ from Kangra Valley, Punjab, 4,500 ft., July 1899 (*G. C. Dudgeon*).

The author has much pleasure in naming this species in honour of his friend Lt.-Col. P. S. Lelean, C.B., C.M.G., R.A.M.C. (his cheery tent-companion during many months of the Sinai-Palestine campaign), whose ingenuity, resource, and untiring energy in the cause of field sanitation contributed in no small degree to the healthy efficiency of the E.E.F.

*Tabanus leleani*, which was the characteristic, and indeed the only representative of its genus met with in the Wadi Ghuzze in 1917, was again common a year later in wadis running down to the Lower Jordan, near Jericho. In the Wadi el Aujah, 19.iv.1918, both sexes were seen resting on stones near the water's edge, while at the beginning of the following June, towards sunset, males were noticed in some numbers sluggishly resting on the precipitous, cliff-like walls of the Wadi el Kelt, a short distance above the spot at which the latter leaves the hills and enters the plain; under such conditions the insects could generally be boxed or captured in tubes with little difficulty. The solitary occasion on which *T. leleani* was observed to attack man has already been recorded.



Fig. 14. *Tabanus leleani*, Austen: a, head of ♂ in profile; b, head of ♀ from front,  $\times 10$ ; b', antenna of ♀ from the side, greatly enlarged.

Apart from its much paler (greyer) appearance, *Tabanus leleani* is distinguished from *T. cordiger*, Mg., by the presence of a band on the eyes, by the row of erect hair on the upper margin of the occiput in the ♂ being much shorter, finer and less conspicuous, by the erect hair on the dorsum of the thorax being shorter and finer, and the covering of pale yellowish, silky hair more appressed.

In general appearance and the majority of the external characters, except as regards size, which is usually distinctly larger, the species described above agrees with *Tabanus albifacies*, Lw., found in Egypt and Persia. *T. albifacies*, however, is distinguishable at once by the presence on the eyes (at least in the ♀) of three bands instead of only a single band. As described by Loew (*Neue Beiträge*, iv, p. 28 (1856)), the wing of *T. albifacies* shows a well-marked appendix to the anterior branch of the third longitudinal vein. In the specimens of *T. leleani* examined such an appendix is absent, except in the case of two ♀♀ from Nasiryah, Mesopotamia (Major W. S. Patton, I.M.S.).

So far as can be judged from the original description of *Tabanus uncinatus*, Lw., the type of which, like that of the foregoing, was obtained in Egypt, *T. leleani* also

resembles that species in general appearance, width of front in ♀, and size. *T. unicinctus* is however distinguishable, *inter alia*, by the veins in the centre of the wing being suffused with brown, by the presence of a dark brown stigma, and by the ground colour of the legs, with exception of a pale ring at the base of the front tibiae, being entirely black.

Finally it may be mentioned that *Tabanus leleani* is nearly allied to *T. unifasciatus* Lw., but may be distinguished by the sharply marked contrast in size between the large and small facets in the eyes of the ♂, and by the greater length and blunter termination of the purple eye band in the ♀.

#### 15. *Tabanus pallidipes*, sp. n. (figs. 15, 16.)

♀.—Length (2 specimens) 11 to 13·6 mm. ; width of head 3·8 to 4·75 mm. ; width of front at vertex 0·4 to 0·5 mm. ; length of wing 8·6 to 10·2 mm.

*Small, greyish species, with bare eyes, narrow front in ♀, two frontal calli in same sex, the upper one narrow and elongate or almost linear in shape ; dorsum of abdomen greyish cinnamon-coloured, darker at distal extremity and with lighter and darker markings ; and pale femora and tibiae.*

*Head* : front and subcallus in ♀ dark olive-buff pollinose, front clothed for most part with minute, appressed, ochreous hairs, and with short dusky hairs on vertex, no trace of an ocellar tubercle, but a tiny, dark mouse grey spot in ocellar region ; face and jowls pallid neutral grey pollinose, clothed with whitish hair ; occiput light olive-grey pollinose, upper hind margin with a scarcely noticeable fringe of short, whitish hair ; *front* in ♀ very narrow, tapering somewhat to lower extremity, about six-and-a-half times as long as its breadth at lower end ; lower *frontal callus* shining dark brown (mummy brown) or cinnamon-brown, oval or quadrate with its angles somewhat produced upwards and downwards, narrowly separate from eye on each side, sometimes with a fine, median, longitudinal groove, upper frontal callus dark brown, linear or narrowly elliptical, indistinctly connected with lower callus by a fine median line ; *eyes* of type *in life* dark brown, unbanded ; *palpi* creamy white or cream-buff, proximal half of distal segment moderately or considerably swollen, distal half acuminate, proximal segment clothed below with whitish hair, distal segment clothed on outer side with minute, appressed, glistening, cream-coloured or yellowish hairs, mixed with minute, appressed, black hairs, which sometimes appear to be in greater number than the pale hairs ; *antennae* cinnamon-coloured, first joint (sometimes second joint also) drab-grey pollinose on outer side, moderately swollen distally, with its upper distal angle considerably produced and partly embracing second joint, first joint clothed on outer side above and distally with minute black hairs, mixed with a certain number of glistening ochreous hairs, and below with longer yellowish hairs, second joint clothed on distal margin with minute black hairs and with its upper distal angle sometimes considerably produced, third joint with expanded portion of moderate depth and having a blunt angle on upper margin a little before middle, expanded portion slightly shorter than annulate portion, which may be infuscated. *Thorax* : dorsum deep neutral grey, anterior border pale neutral grey, lateral borders and five more or less distinct longitudinal stripes pale smoke grey or smoke grey, outer stripes visible only behind.



transverse suture above bases of wings, all stripes sometimes difficult to distinguish; dorsum clothed with short, appressed, glistening, pale ochreous or greyish hair, on darker areas mixed with short, erect, blackish hair, ground colour of rather less than distal half of scutellum when denuded sometimes greyish cinnamon-coloured; swelling occupying depression at each end of transverse suture clothed with fairly long, fine black hair, mixed with yellowish hair, which predominates above; pleurae and pectus pale smoke-grey pollinose, clothed with whitish hair. *Abdomen*: dorsum from second to sixth segments inclusive with four longitudinal rows of elongate, more or less oblique, blackish brown spots, four spots on each segment, namely an admedian pair (extending from anterior margin outwards, nearly or quite reaching hind margin and enclosing an anteriorly directed, drab-grey, truncated, median triangle), and a lateral oblique spot on each side extending backwards and outwards from anterior margin, partly cutting off basal angle but not reaching hind margin, area between lateral and admedian dark brown spots on each side of each segment thus taking shape of a more or less oval or elliptical oval, backwardly and outwardly directed, drab-grey spot; seventh tergite drab, without darker markings; median drab-grey triangles resting on hind margins and extending to front margins of segments, with their posterior angles somewhat produced outwards; drab-grey or greyish cinnamon areas of dorsum clothed with minute, appressed, glistening, yellowish hairs (hair on extreme lateral extremities of anterior tergites more whitish), blackish brown areas of dorsum clothed with minute, appressed, black hairs, longer black or blackish hairs also present on lateral extremities and posterior angles of last three tergites; venter light pinkish cinnamon (hind margins of second to sixth segments inclusive paler -light buff), suffused with pale smoke-grey or pale drab-grey pollen, and clothed with minute, appressed, glistening, cream-coloured or pale yellowish hair; ventral scute of seventh segment bearing the usual coarse, erect, black hairs. *Wings* hyaline, clear or tinged with light drab, veins lighter or darker olive-brown, auxiliary and first longitudinal veins, and proximal portion of second and fifth veins, paler (tawny-olive or cinnamon); *stigma* faintly tinged with yellowish or almost colourless, inconspicuous. *Squamae* whitish or ivory yellow, borders cream-coloured. *Halteres* ivory yellow or cream-coloured, distal extremity of stalks slightly darker, at least in dried specimens. *Legs*: coxae drab-grey or smoke-grey pollinose (ground-colour of front pair tawny-olive), clothed with whitish hair; femora cinnamon-buff or pinkish cinnamon, pale smoke-grey pollinose on outer side, clothed with whitish or pale yellowish hair, front femora also with black hairs above; tibiae warm buff or cinnamon-buff (distal fourth or rather more than distal fourth of front pair brownish), clothed with minute, appressed, glistening, cream-coloured or pale yellowish hair, infuscated distal extremities of front pair and extensor surfaces of all tibiae also largely clothed with minute black hairs, hind tibiae on outer side with a fringe of longer hair, in which in some specimens cream-coloured in others black hairs predominate; front tarsi dark brown or dark sepia coloured, third and fourth joints somewhat expanded, middle and hind tarsi mummy brown (first joints paler at base), all tarsi clothed above with minute black hairs, front tarsi sometimes also with yellowish hairs on proximal two-thirds of anterior surface.



Lower Jordan Valley and Jerusalem: type from Wadi el Kelt, Jericho Plain, 11.vi.1918; a second specimen labelled "Jérusalem," received in 1912 from the Zoologisches Museum, Berlin.

The species just described, individuals of which, as will have been seen, sometimes show considerable variation in size, appears to be allied to the Austrian *Tabanus mikii*, Brauer, from which however it is distinguishable, *inter alia*, by the much paler legs; in *T. mikii* the femora, front tarsi and tips of the front tibiae are black.



Fig. 15. *Tabanus pallidipes*, Austen, ♀.  $\times 4$ .

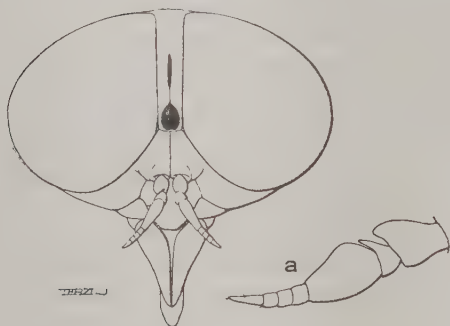


Fig. 16. *Tabanus pallidipes*, Austen, head of ♀ from in front,  $\times 10$ ; a, antenna from the side, greatly enlarged.

*Tabanus pallidipes* is possibly identical with the Arabian *T. arabicus*, Macq., in which the femora were stated by Macquart (*Mém. Soc. Roy. Lille*, 1838, p. 299: *Dipt. Exot.*, i, 2, 1838, p. 183) to be tawny or fawn-coloured (*fauves*). The original description of this species, however, which makes no mention of the dimensions of the front in the ♀ and leaves the abdominal markings to the imagination of the reader, is so brief and faulty that, in the absence of the typical specimens, precise identification is impossible.

The species characterised above is also allied to *T. laetelinctus*, Becker, the typical series of which was obtained in Persian Baluchistan; so far as can be judged from Becker's description, however, *T. pallidipes* is distinguished, *inter alia*, by the much narrower front in the ♀, and by the infuscated tarsi.

16. ***Tabanus dalei***, sp. n. (figs. 17, 18.)

♂.—Length (1 specimen) 12.5 mm.; width of head 4.75 mm.; length of wing 11 mm.

*Dorsum of thorax dusky neutral grey, shining; dorsum of abdomen slate-black; second and four following segments with posterior transverse bands of appressed, glistening, silvery-white hair; eyes bare; wings hyaline, extreme base, costal and subcostal cells, and proximal half (narrow portion) of marginal cell ochraceous tawny, contrasting sharply with remainder of surface; legs black, extensor surfaces of all tibiae, except at distal extremities, clothed with glistening whitish or yellowish hair.*

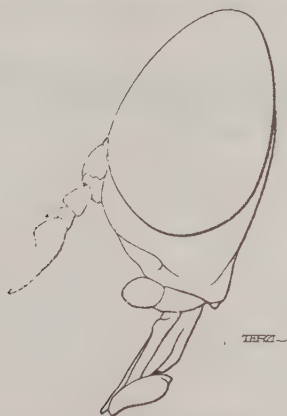


Fig. 17. *Tabanus dalei*,  
Austen, head of ♂ in pro-  
file. × about 10.

*Head of ♂ small, frontal triangle, face and jowls smoke-grey pollinose, face and jowls clothed with whitish hair; occiput neutral grey pollinose, posterior margin fringed at sides and above with erect, yellowish hair, longer in region of vertex, and mingled on each side of vertical region with a certain number of black or blackish hairs; ocellar tubercle inconspicuous, sunk in vertical triangle; eyes in ♂ each with an area of moderately enlarged facets abutting on inner margin, but such facets progressively diminishing in size towards exterior and merging gradually into remainder, to which they nowhere present a sharp contrast; palpi in ♂ dark mouse grey pollinose, clothed with whitish hair, terminal segment small, bluntly elliptical ovate, not pointed at distal extremity; first joint of antennae in ♂ blackish mouse grey, scarcely swollen distally, sparsely clothed with short yellowish hairs, second joint blackish brown, with a few yellowish hairs on inner side and minute black hairs on upper distal angle, which is considerably produced, third joint dark clove brown or blackish brown (slightly paler at extreme base), expanded portion of moderate depth or fairly deep, at least in ♂, with a blunt but prominent*

angle about middle of upper margin, which is moderately excavated in front of the angle. *Thorax*: dorsum clothed with fine, erect, silky, pale yellowish hair, scattered among which is a certain number of fine black or blackish hairs, which on scutellum are much more numerous and even appear to predominate, anterior border of dorsum with commencements of two light greyish olive, pollinose, longitudinal stripes; swelling occupying depression at each end of transverse suture agreeing in coloration with remainder of dorsum and similarly clothed with hair, but without black hair; pleurae and pectus clothed with yellowish white or whitish hair, the tuft of long hair on hind margin of mesopleura conspicuously ochreous at base; pleurae neutral grey pollinose above, pectus and lower part of pleurae deep neutral grey. *Abdomen*: dorsum of first (visible) segment neutral grey pollinose (greyish olive pollinose on each side), clothed in centre and on each side with glistening yellowish white hair; posterior transverse bands of appressed, glistening, silvery-white hair, on second to sixth segments inclusive, expanded in middle line so as to form anteriorly directed triangles; silvery-white hair also extending



Fig. 18. *Tabanus dalei*, Austen, wing of ♂.  $\times 10$ .

from front to hind margins on lateral borders of segments referred to; on third, fourth and fifth segments commencement of expansion of hind border on each side includes a certain amount of appressed, glistening, ochreous hair; ground-colour of hind margins of first six tergites cinnamon-drab; dorsum, except as already stated, clothed with short, appressed, black hair; venter deep neutral grey pollinose (hind margins of segments as on dorsum), clothed with silvery white or appressed silvery white hair, which is more conspicuous on hind borders of segments, and in central area of anterior part of second, third and fourth segments is largely if not entirely replaced by minute black hairs. *Wings*: veins dark brown or mummy brown, proximal portion of fifth longitudinal vein, forming lower boundary of second basal cell, ochraceous-tawny and, like corresponding portion of fourth longitudinal vein, narrowly suffused with similar colour; anterior branch of third longitudinal vein without appendix; *stigma* ochraceous tawny, indistinguishable from coloured costal border; proximal portion of marginal cell with a narrow hyaline streak on its anterior border. *Squamae* ivory yellow, borders cream-buff or cream-coloured. *Halteres*: knobs clove brown, stalks mummy brown. *Legs*: coxae neutral grey pollinose, clothed with yellowish white hair; middle and hind femora and posterior surface of front femora clothed with

glistening, yellowish white or ochreous hair; pale hair on hind tibiae in ♂ fairly long and bushy; distal extremities of tibiae and upper surfaces of tarsi clothed with minute black hairs.

Near Jerusalem, May, 1918 (*Captain (acting Lt.-Col.) W. J. Dale, O.B.E., R.A.F.C.*).

The species characterised above, with which the author is glad to have the opportunity of associating the name of its discoverer (A.D.V.S., XXth Corps, 1917-19), is not closely related to any of its congeners known to the writer, and, owing to the ochraceous-tawny coloration of the base and proximal two-thirds of the costal border of the wing, is readily distinguishable from all other species described or mentioned in the present paper.

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## NOTES ON SOME CULICIDAE COLLECTED IN LOWER MESOPOTAMIA.

By LIEUT. P. J. BARRAUD, R.A.M.C.

From October 1918 to February 1919 inclusive I was stationed at Basrah, Lower Mesopotamia, and during that time I was able to devote some time to the collecting of CULICIDAE and their larvae.

My investigations were necessarily confined to a somewhat restricted area, possibly five miles from north to south, and one mile wide, embracing the districts known as Ashar, Makina, and Magil, along the right bank of the Shatt-el-Arab river. Some collecting was also done on the left bank from Tonooma, opposite Ashar, northwards. Practically the whole of this ground is within the cultivated belt lying between the river banks and the desert, and is intersected by numerous creeks, and irrigation canals. There were also in some places many pools and swampy areas forming good collecting ground.

The wet season commenced towards the end of November and continued to the end of my stay, but the rainfall was intermittent and not considerable in amount. In December there were several violent storms with heavy rain for a time.

From official temperature records I made the following notes :—

October 1918.—Maximum shade temperature between 102°F. (5th and 7th) and 88°F. (23rd and 30th). Minimum shade between 75 (5th) and 57 (24th).

November 1918.—Maximum shade between 89 (3rd, 6th and 7th) and 69 (9th). Minimum shade between 63 (7th) and 49 (several days in the last week).

December (up to 22nd, beyond which date I have no records).—Maximum shade between 76 (1st) and 60 (10th, 11th and 12th). Minimum shade between 60 (17th) and 38 (13th).

There was no frost or snow throughout the winter.

The “main river” referred to in the following notes is the Shatt-el-Arab, formed by the junction of one of the mouths of the Euphrates and the Tigris, about five miles north of Ashar.

I am much indebted to Dr. Guy A. K. Marshall, Imperial Bureau of Entomology, and Mr. F. W. Edwards for kind assistance in the working out of my material; to Major S. R. Christophers, I.M.S., for giving me facilities and help in my work at Basrah; and to Capt. H. E. Shortt, I.M.S., for his valued companionship on many a delightful excursion.

### **Anopheles stephensi**, Liston.

This appears to be the chief malaria carrier of the district and bred continuously during the time I was at Basrah. Numbers of adults and larvae were found in October, November and December.

The larvae occur chiefly in the clearer pools in the cultivated area. On 14th January 1919 I found about one hundred larvae in a small pool near Ashar, many of them full-grown. Adults were bred out in the laboratory during the following ten days. In February only a few larvae were found.

**Anopheles pulcherrimus**, Theo.

Anti-malarial work in the cultivated belt seems to have had more effect on this species than upon the preceding one, and the numbers have been greatly reduced.

Large numbers of larvae were, however, found in pools near the edge of the desert in October. Sometimes the larvae of this species and those of *A. stephensi* occur together in the same pool, but those of *A. pulcherrimus* usually prefer weed-grown stagnant and more brackish water. Camps near the desert are at times infested with large numbers of *A. pulcherrimus* adults.

**Anopheles sinensis**, Wied.

Major Christophers has described a new form of this species occurring in Mesopotamia, viz. var. *mesopotamiae* (Indian Jl. Med. Res. iii, p. 196). The species is not very common in the Basrah area. On 18th December I saw it for the first time and caught three females and some small larvae possibly of this species, in the marshes on the left bank of the main river. Subsequently a few more were taken in the same place. On 18th January one male emerged in the laboratory from a nymph collected in Makina area. Later on more were found on the banks of a creek between Magil and the Euphrates.

**Culex fatigans**, Wied.

Abundant throughout the cultivated area during my stay. The larvae were found in extraordinary numbers in some pools, appearing as a dark mass beneath the surface.

**Culex pipiens**, L.

Far less common in my experience than *C. fatigans*. I did not identify any larvae of this species until January. In mounting numbers of larval skins I did not find much difficulty in separating the two species.

**Culex modestus**, Fic.

Some larvae of this species were collected in October and November, but they were not very numerous. In one case they were found in a pool containing numbers of *A. stephensi* and *A. pulcherrimus*.

**Culex tritaeniorhynchus**, Giles.

Larvae were found in October and November in Ashar and Makina areas in small numbers.

**Culex tipuliformis**, Theo.

Larvae of this species were not found until January, first in isolated pools on the left bank of the main river, and later in larger numbers in Ashar district.

**Stegomyia fasciata**, F.

Very few specimens met with in Basrah area during my stay, and no larvae found. On 23rd November, when visiting Mohommerah, lower down the main river on the Persian side, adults were found in small numbers in a building on the river bank.

***Ochlerotatus dorsalis*, Mg.**

This mosquito was found quite commonly over the whole area, both adults and larvae, and is the only species of those mentioned which occurred in about the same numbers in the cultivated belt and in the outlying places visited on the edge of the desert. In one case larvae were found in a collection of rain-water in the bottom of a boat in Ashar town, and some were found in pools in the desert at some distance from cultivation. Adults and larvae occurred from December to February.

***Theobaldia longiareolata*, Macq.**

The first specimen emerged on 27th December in the laboratory, the larva having been found in Ashar area. Towards the end of January and in February the larvae became more numerous, being found chiefly in the deeper pools. The pupa may often be seen about four inches below the surface of the water and appears to retain that position by gentle movement, remaining at that depth for quite a long time.

***Theobaldia annulata*, Schranck.**

Larvae were not found until 24th February and were then not uncommon in Ashar district.

The adults have the thorax and abdomen almost uniformly light reddish brown, with very little trace of the normally conspicuous abdominal banding. This interesting colour modification, which is unaccompanied by any structural change, is no doubt adaptive to desert conditions. A similar variation has been noticed in several other mosquitos.

Port Said, June 1919.

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ON A NEW MUTILLID PARASITE OF *GLOSSINA MORSITANS*,

By ROWLAND E. TURNER.

**Mutilla auxiliaris**, sp. nov.

♀. Nigra; thorace brevissimo, fusco-ferrugineo; tergitis tribus basalibus fascia apicali angusta pallide aureo-sericea; area pygidiali nulla.

♂. Niger; prothorace, mesonoto, scutelloque ferrugineis; tergitis quatuor basalibus albido-fimbriatis; alis fuscis, basi dilutioribus, posticis basi hyalinis, venis nigris, calcaribus intermediis posticisque pallidis.

Long. ♀, 5 mm.; ♂, 7 mm.

♀. Mandibles simple; antennae rather stout; second joint of the flagellum short, scarcely longer than the third; the apical joint rather slender, longer than the penultimate. Head rugosely punctured; eyes oval, situated nearer to the base of



Fig. 1. *Mutilla auxiliaris*, Turner, sp. n., ♀♂.

the mandibles than to the hind margin of the head. The whole insect rather sparsely clothed with long blackish hairs. Thorax as broad as the head, punctured-rugose, almost as broad in the middle as long; the sides distinctly, but not strongly, convex; the anterior margin not quite straight, widely and very shallowly emarginate, the posterior slope rather abrupt, no scutellar tubercle, the sides of the apical slope with several minute teeth. Abdomen strongly punctured, the punctures more or less confluent longitudinally; first tergite broad, transverse, almost as broad as the second, abruptly truncate anteriorly; second tergite as broad in the middle as long, the sides distinctly, but not very strongly convex; no pygidial area. Hind tibiae with a row of three spines; tarsal ungues simple.

♂. Clypeus strongly concave, shallowly emarginate at the apex; bordered laterally by carinae which converge towards the base, the apical margin with several pale setae. Mandibles bidentate on the right side, tridentate on the left; labrum transverse. Head closely punctured, the clypeus smooth and shining; antennal tubercles strongly developed, the front with an obscure longitudinal sulcus which does

not extend to the anterior ocellus. Second joint of the flagellum distinctly shorter than the third, the fourth slightly longer than the third. Pronotum and mesonotum evenly and rather strongly punctured, the mesonotum short and broad; scutellum more coarsely punctured; median segment short and broad, very coarsely reticulate. Abdominal tergites rather less strongly punctured than the thorax; first tergite short, transverse, narrower than the second which is very broad, being nearly three times as broad at the apex as long, with the sides strongly convex; seventh tergite broadly subtruncate at the apex. Second abscissa of the radius longer than the third, first transverse cubital nervure curved inwards, second curved outwards, first recurrent nervure received close to the middle of the second cubital cell, second beyond two-thirds from the base of the third cubital cell.

PORTUGUESE EAST AFRICA: Kanezi, Mossurise district, vii. 1918 (*C. F. M. Swynnerton*).

Bred from puparia of *Glossina morsitans*, 5 ♀♀, 1 ♂.

Allied to *M. glossinae*, Turn., but easily distinguished by the shorter thorax and second tergite of the female; and in the male by the much more distinct transverse carina at the base of the dorsal surface of the first tergite and the distinctly shorter second tergite. The two species are very closely related, the neuration of the males being very similar, both differing in this and many other respects from *M. benefactor*, Turn., the only other species which has yet been bred from *Glossina*.

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## NOTES ON THE IDENTIFICATION OF ANOPHELINAE AND THEIR LARVAE IN THE ZANZIBAR PROTECTORATE.

By W. MANSFIELD-ADERS,

*Economic Biologist, Zanzibar Government.*

Medical Officers and others interested in tropical sanitation often find great difficulty in rapidly identifying adult mosquitos. Four Anophelines have been found in the Zanzibar Protectorate, two of these being well-known malaria carriers. The identification of the two latter with the aid of a pocket lens is quite simple.

### *Adult Anophelines.*

#### **Anopheles costalis, Lw.**

This is the commonest Anopheline in the Protectorate and the species most often brought in by the mosquito brigade for identification. It is a large insect and can at once be recognised by the golden yellow stippling on the first pair of legs, which is specially marked on the tarsal joints.

#### **Anopheles funestus, Giles.**

Adults of this species are very uncommon in the town, but are constantly captured in the outlying districts. This Anopheline is easily recognised by its small size and generally black colour. There are no signs of stippling on the legs, therefore it cannot be confused with *A. costalis*.

#### **Anopheles mauritanus, Grp.**

Adults of this form are very rarely captured. It is one of the easiest species to identify, its chief characteristics being its large size, the very distinct long black spots on the costal vein, and especially the pure white tarsal joints of the hind pair of legs.

#### **Anopheles squamosus, Theo.**

This mosquito somewhat resembles *Stegomyia fasciata* in having the legs spotted with black and white markings, but the outstanding characteristic peculiar to it is the presence of lateral abdominal hair tufts.

### *Anopheline Larvae.*

The identification of the Anopheline larvae is a more difficult problem, though three of them, *A. costalis*, *A. funestus* and *A. mauritanus*, have marked characteristics.



**Anopheles costalis, Lw.**

This is the commonest Anopheline larva. It is generally found in small collections of rain-water, such as road-side puddles, borrow-pits, water-holes (dug by the natives for storing water), shallow swamps surrounded by grass, occasionally in cement tanks, oftener in those with algid growth attached to their sides, at times in rain-water collected in dug-out canoes and boats. The larvae of this species vary greatly in colour, some being quite light, some dark, others almost green, the variations being caused by the type of food ingested.

The larva has a small head, the hairs on the first three segments of the abdomen are not markedly feathered and the palmate hairs from the second to the seventh segment are not very conspicuous.

**Anopheles funestus, Giles.**

These larvae are generally found in backwaters of streams and at the edge of the sluggish rivers where the water is overhung by grass or other vegetation. Occasionally they are found in association with *A. costalis* in the Zanzibar

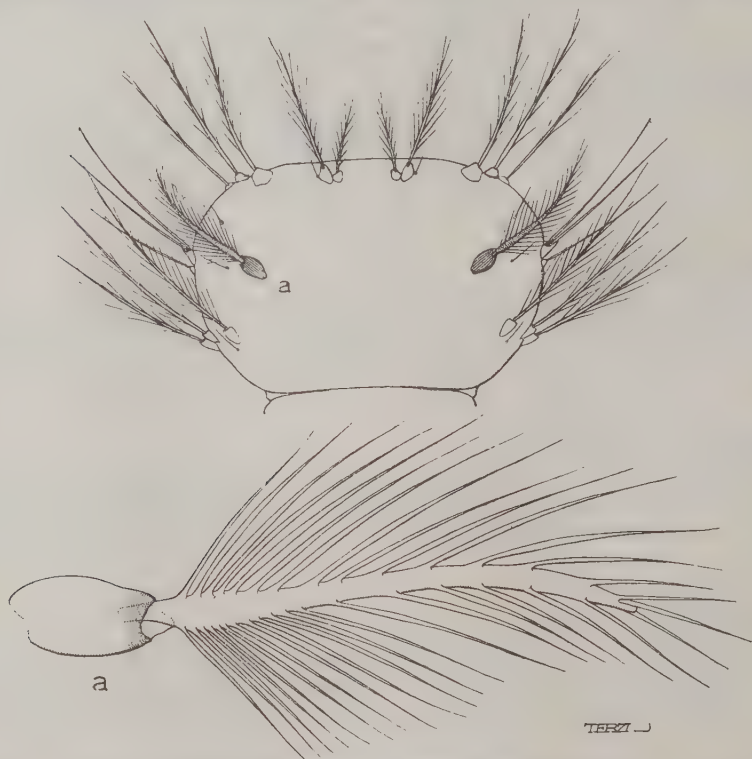


Fig 1. Thorax of larvae of *Anopheles funestus*, Giles (4th instar); a, one of the plumose hairs, greatly enlarged.

Protectorate. The larvae are small and black in colour and much more heavily plumed than those of *A. costalis*. With a pocket lens a pair of thick feathered hairs

springing from a chitinous pocket near the middle of the thorax are easily recognisable (fig. 1, *a*). This characteristic alone suffices to distinguish the larvae of *A. funestus* from those of the other island species. It must be remembered that the larvae of *A. costalis* carry the same hairs, but these are not nearly so conspicuous and are difficult to detect even with a lens. The palmate hairs are better defined than those of *A. costalis*.

### **Anopheles mauritanus, Grp.**

The larvae are easily identified; the antennae carry a conspicuous hair-tuft in the median region and there are two very characteristic fan-shaped tufts of short black hairs above the mouth-brushes. These two characters are sufficient for the identification of these larvae. The abdomen in both old and young larvae is marked with whitish bands. The living larvae have the peculiar habit of twisting themselves into an S-shape, a habit which I have not noticed in any other Anopheline larva.

### **Anopheles squamosus, Theo.**

The larvae of this Anopheline are unknown to me.

#### *Technique and Methods of Control.*

A simple method of examining mosquito larvae is to remove one from the glass collecting jar by means of a pipette, place it in a drop of clean water on a microscope slide, and anaesthetise it by placing near it a pledget of cotton-wool soaked in chloroform covering all with an inverted petri dish for a few minutes. The larva can then be moved about and turned by means of a fine dissecting needle with a minimum of injury to its finer hairy structures.

The Public Health Officer will be greatly aided in his work by a mosquito brigade of native boys trained to recognise the larvae of the three genera *Anopheles*, *Culex* and *Stegomyia*. We supply our mosquito brigade with glass jars for collecting larvae and with long-handled white enamelled iron ladles, which make most efficient dippers and in which the most minute larvae are easily seen against the white background.

A further valuable means of indicating the presence of mosquitos and of obtaining specimens of larvae is the use of mosquito traps. The traps used are ordinary wooden tubs about  $2\frac{1}{2}$  feet in diameter cut down to a height of 6 inches. These are sunk till their rims are flush with the ground, soil to the depth of some 2 inches is spread in them, water is poured on to the requisite depth and finally some aquatic weeds are floated on the surface. These traps, under the control of the mosquito brigade, are placed at intervals round the periphery of the town.

The traps are examined every six days for the presence of larvae, all species being recorded. The method of examining the traps is as follows. Each trap is visited by an inspector on the sixth day, and its whole contents after agitation, are emptied into a bucket bearing the same number as the trap. The buckets are brought to the Health Office for critical examination. The contents of the buckets are strained through fine muslin, the residue and debris left adhering to the muslin being washed down into a large white enamelled dish, in which the larvae can easily

be identified. The muslin is soaked and washed in clean water after each examination. Generally mixed infections of larvae are found, and these have proved of great use in training the staff of the mosquito brigade.

All members of the mosquito brigade are trained to capture and identify adults, a most valuable adjunct to the larval index of a town, and the senior members are taught to recognise males and females of *Anopheles*, *Culex* and *Stegomyia*.

For obtaining adults they are supplied with short glass tubes about six inches long and one inch in diameter; a plug of cotton-wool soaked with chloroform is placed in the bottom of each and the tube is corked. With this simple contrivance resting adults can be caught with ease. The adults so collected are pinned out by their respective captors and on their return to the Health Office are submitted for examination. By these means we secure an ample supply of specimens for exchange or for teaching purposes.

The training of natives requires a great amount of patience, but if one is able to interest them in their work, the trouble spent on explaining the life-history and habits of the insects they are expected to control is well repaid.

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# THE MOSQUITOS OF FAR EASTERN PORTS WITH SPECIAL REFERENCE TO THE PREVALENCE OF *STEGOMYIA FASCIATA*, F.

By A. T. STANTON,

*Bacteriologist, Institute for Medical Research, Federated Malay States.*

## I. INTRODUCTION.

The danger of the introduction of yellow fever into Oriental countries has been the subject of much discussion since Sir Patrick Manson first drew attention to it in 1903. In 1911 Major (now Lt.-Col.) S. P. James, I.M.S., was deputed by the Government of India to study the conditions in the endemic areas of Central America and in the principal sea-ports between that country and India. His report, published in 1913, was a most valuable contribution to our knowledge of the problems surrounding this subject. Among other recommendations, Major James suggested that further inquiry should be made with reference to the occurrence of *Stegomyia fasciata* in Far Eastern ports.

Any measures that may be devised for the protection of India and the Far Eastern colonies from yellow fever must take account of the distribution and prevalence of the known carrier of the disease, perhaps also of its near allies, and of the sanitary and other circumstances affecting the prevalence of mosquitos generally. It was considered desirable to supplement the data hitherto obtained, and in September 1915 at the suggestion of the Imperial Bureau of Entomology I was instructed by the Government of the Federated Malay States to pursue these inquiries.

The following ports were visited between October 1915 and March 1916; Bangkok (Siam), Saigon (Cochin-China), Haiphong (Tonkin), Canton (South China), Batavia, Samarang and Soerabaia (Java), Makasser (Celebes) and Tjilatjap (Java). Through the courtesy of several correspondents I have been able also to examine specimens from other places in this region. It was not found possible to complete the observations by a survey of the ports of China and Japan as had been planned.

Reports of the observations (with specimens of mosquitos from the different ports) were sent to the Imperial Bureau of Entomology as the work progressed and these reports are now reproduced in a form convenient for reference. There is added a summary of the observations and of the conclusions that can be drawn from a study of them.

I am under obligation to many officers of the Governments of Siam, French Indo-China, and the Netherlands East Indies for generous assistance in connection with the enquiry, especially to Drs. M. Carthew, M.O.H., and Malcolm Smith (Bangkok), Dr. A. Denier (Saigon) and Drs. W. T. de Vogel, N.F. Lim, H. Werkman, L. S. von Römer and M. L. van Breemen (Java). To Dr. G. A. K. Marshall, Director of the Imperial Bureau of Entomology, and Mr. F. W. Edwards, of the British Museum, I am indebted for confirmation or correction of my identifications of mosquitos.



## II. THE PORTS VISITED.

**Bangkok.**

Bangkok, the modern capital of Siam, is situated on both banks of the River Menam, in latitude  $13^{\circ} 45'$  North and longitude  $100^{\circ} 30'$  East, about twenty-five miles up-stream from the bar at the river's mouth. The city proper, the government offices, banks and business houses are on the left bank of the river; on the right bank are rice mills and other industries and the dwellings of a large part of the native population. The city is intersected in all directions by a network of canals. The estimated population is 625,000.

*Trade.*—The trade of the port is mainly with Singapore, Hong Kong, Swatow and Hoihow. There is also direct steamer connection with Saigon and Batavia.

*Temperature and Rainfall.*—The monthly mean temperature of Bangkok is above  $80^{\circ}\text{F}$ . for all months of the year except November, December and January. The annual mean rainfall is about 57 inches. The months May to October are wet months; December, January and February are dry.

*Water Supply.*—A public water supply for Bangkok was installed in November 1914. The water is taken from the Menam about twenty-five miles north of the city, carried by a canal to the filtering plant at Bangkok and thence distributed in pipes over the greater part of the city on the left bank of the river.

In addition to this public supply, which is as yet available for only a small part of the population, there are artesian wells, shallow wells and the river and canals, all of which are drawn upon. The storage of water in jars for household purposes is the rule in Bangkok among the poorer classes.

*Sanitation and Quarantine.*—The sanitary administration of the city is controlled by the Ministry of Local Government. Provision is made for three European medical officers, a Bacteriologist, and a number of Siamese assistants. No special measures are in operation for the reduction of mosquitos.

This department also deals with quarantine matters. The quarantine station, is situated at Koh Phra, an island about 60 miles from Bangkok. It is proposed to construct a new station on the river about 15 miles from the city.

*Mosquitos.*—An investigation was made in late October and early November of the distribution of mosquitos in all parts of the city by examining specimens taken in houses and by the identification of larvae taken in artificial and natural collections of water in the neighbourhood of houses.

The following list of species is in order of comparative frequency of their occurrence.

(A). Adult mosquitos taken in houses :—*Culex fatigans*, Wied.; *Stegomyia fasciata*, F.; *Stegomyia albopicta*, Skuse (*scutellaris* Theo.); *Mansonioides uniformis*, Theo.; *M. annulipes*, Walk.; *Culex gelidus*, Theo.; *C. concolor*, R. D.; *C. sitiens*, Wied.; *Mansonioides annuliferus*, Theo.; *Anopheles sinensis*, Wied.; *A. sinensis* var. *peditaeniatus*, Leic.; *A. rossi* var. *indefinitus*, Ludl.; *A. barbirostris*, Wulp; *A. fuliginosus*, Giles; *A. fuliginosus* var. *nivipes*, Theo.; *Culex halifaxi*, Theo.; *C. fuscocephalus*, Theo.; *Uranotaenia cancer*, Leic.; *Anopheles tessellatus*, Theo.

(B). Larvae from artificial collections of water : jars, tubs, barrels, tins, etc. :—*Stegomyia fasciata* ; *Armigeres obturbans*, Walk. ; *Stegomyia albopicta* (*scutellaris*) : *Cyathomyia brevipalpis*, Giles ; *Toxorhynchites immisericors*, Walk. ; *Culex halifaxi* ; *C. fatigans* ; *Anopheles rossi* var. *indefinitus*.

(C). Larvae from natural collections of water : pools, canals, ditches, etc. :—*Culex fatigans*, *C. gelidus*, *Armigeres obturbans*, *Culex concolor*, *Anopheles rossi* var. *indefinitus*, *A. sinensis*.

The cannibal larvae of *Toxorhynchites immisericors*, Walk., were here frequently encountered in water-jars, and their astonishing voracity for *Stegomyia* larvae, as many as twenty-five of the latter being devoured in a single night, made one think of the possibility of their utilisation in *Stegomyia* reduction. In Bangkok throughout the city mosquitos are numerous and *Stegomyia fasciata* is abundant. The habits of the people in the storage of water and the restricted distribution of the public water supply combine to make the task of its reduction a very difficult one.

### Saigon.

Saigon, the capital of Cochin-China, is situated on the banks of the River Saigon, a tributary of the Donnai, in latitude 10° 46' North and longitude 106° 30' East. The town lies about 40 miles up-stream from Cape St. James at the mouth of the river Donnai and is accessible to the largest steamers. The population of Saigon is about 70,000. The city of Cholon, which for practical purposes is a part of the port, is situated about four miles further up-stream and is connected with Saigon by a steam tramway. Cholon is the centre of much commercial activity in connexion with the milling and export of rice, the staple product of Cochin-China. The population of Cholon is 165,000.

*Trade*.—The trade of the port is with Hong Kong, Singapore, Manila, Japan and the Netherlands East Indies by direct services, and with Europe by way of intermediate ports.

*Temperature and Rainfall*.—The monthly mean temperature is above 80°F. for all months of the year except December, when it falls slightly. The annual mean rainfall is about 65 inches. The rainy season begins about the middle of May and ends about the middle of November, January to March being the driest months.

*Water Supply*.—The public water supply of Saigon is collected from a number of surface wells within the city and from a small catchment area about two miles outside it. The supply is now intermittent, necessitating storage in tanks or jars. A plan for a continuous high pressure supply is under consideration.

*Sanitation and Quarantine*.—The sanitary administration is controlled by the Civic Corporation through their medical officer of health, who is assisted by sanitary inspectors. Though no special measures are directed against mosquitos, the efficient civil sanitary service ensures that breeding places are not neglected.

The quarantine service is directed by the Chief of the Health Service of Cochin China, an officer of the Sanitary and Medical Services of Indo-China. The quarantine station is situated at Nhabé, fifteen miles down-stream from the city ; the buildings, accommodation and equipment are excellent.

These services throughout Indo-China are well maintained. All the principal ports and many of the smaller ones are provided with rooms for disinfection and mobile apparatus for the disinfection of ships.

*Mosquitos*.—The following species were met with, given in order of frequency.

(A). Adult mosquitos taken in houses:—*Culex fatigans*, *Stegomyia fasciata*, *S. albopicta* (*scutellaris*), *Armigeres obturbans*, *Mansonioides uniformis*, *Culex gelidus*, *C. sitiens*, *C. concolor*, *Anopheles rossi* var. *indefinitus*, *A. sinensis*.

(B). Larvae taken in artificial collections of water:—*Stegomyia fasciata*, *S. albopicta* (*scutellaris*), *Ochlerotatus gubernatorius*, Giles, *Cyathomyia brevipalpis*, *Culex concolor*.

(C). Larvae taken in natural collections of water:—*Culex fatigans*, *C. gelidus*, *C. concolor*, *A. rossi* var. *indefinitus*.

At the time of my visit, in November towards the end of the rainy season, mosquitos were not numerous in Saigon, but *Stegomyia fasciata* was not uncommonly met with. In the native city of Cholon larvae of this species were common.

In the annual report for 1914 of the "Ambulance du Cap St. Jacques" Major J. E. Rencurel describes an outbreak of fever of obscure causation among officers and their families. A further small outbreak at Cape St. James occurred in 1915 and similar cases were observed at Saigon. Major Rencurel identified this fever with the "six day fever of ports" described by Leonard Rogers and attributed its spread to a biting insect, mosquito or fly. Certain officers who had experience of the fever and of the conditions at Cape St. James entertained the suspicion that the disease might be related in some way to yellow fever.

### Haiphong.

Haiphong is the shipping port for Hanoi and other commercial centres in Tonkin and for the Chinese province of Yunnan. It is situated in latitude 20° 50' North and longitude 106° 42' East, on the banks of the rivers Cua Cam and Song Tam Bac. These rivers are joined by several channels with the river Song Koi, a great waterway connecting Yunnan with the Gulf of Tonkin. The banks of the rivers are low and consist of alluvial mud, from which the present site of the town of Haiphong has been reclaimed. Scattered throughout the town are extensive pools and areas of marsh land. The population of Haiphong is about 45,000.

*Trade*.—Haiphong is accessible to large ocean-going steamers. The sea-borne trade of the port is mainly with Hong Kong, Saigon, Pakhoi in the Chinese province of Kwang-si, and Hoihow on the island of Hainan.

*Temperature and Rainfall*.—The monthly mean temperature rises above 80°F. only during the months June to September. From December to February it is about 62°F. The annual mean rainfall is about 69 inches, May to October being the rainy months.

*Water Supply*.—The public water supply is a continuous high pressure supply drawn from storage reservoirs in the hills and distributed over the whole area of the city.

*Sanitation and Quarantine*.—These services are controlled by the director of Health Services of Tonkin, whose headquarters are at Hanoi and who is represented at Haiphong by an official of the department.



The quarantine station is at Binh-Dong, about ten miles down-stream. There is a complete equipment of buildings, materials, and staff.

### *Mosquitos.*

(A). Adult mosquitos taken in houses:—*Culex fatigans*, *Stegomyia fasciata*, *S. albopicta* (*scutellaris*), *Armigeres obturbans*, *Mansonioides annuliferus*, *M. annulipes*, *Culex sitiens*, *Anopheles rossi* var. *indefinitus*, *A. sinensis*, *A. minimus*, Theo.

(B). Larvae taken in artificial collections of water:—*Stegomyia fasciata*, *S. albopicta* (*scutellaris*), *Armigeres obturbans*.

(C). Larvae taken in natural collections of water:—*Culex fatigans*, *C. sitiens*.

At the time of my visit to Haiphong in December the temperature was low, 64° - 72°F., and mosquitos were few in number. A few specimens of *Stegomyia fasciata* were taken.

Dr. P. L. Simond, Inspector General of the Sanitary and Medical Services of Indo-China, reports (Bull. Soc. Med. Chir. Indochine, vii. 2, 1916) that he found a specimen of *Stegomyia fasciata* in Hanoi, Tonkin, in November 1915, but considers that the species is rare in this region. Dr. Simond has also made observations in Cochinchina, where he found specimens of *Stegomyia fasciata*, but concludes that it is a rare species. This conclusion was not borne out by my examination of breeding places in Saigon.

### **Canton.**

Canton, the capital of the Chinese Province Kwang Tung, is situated on the Chu Kiang or Pearl River in latitude 23° 7' North and longitude 113° 14' East. The city proper extends to a breadth of about two miles and is about six miles in circumference, being enclosed by a wall. The suburbs extend along the river for about five miles. The population has been estimated by the Customs authorities at 2,500,000.

*Trade.*—Ample means of communication exist between Canton and Hong Kong, a distance of 95 miles by water and 112 miles by railway. Foreign steamers and a large number of native craft ply daily. There is daily steamer communication with Macao, and regular communication with Wuchow and other West River towns and with Shanghai and other Chinese ports. Ocean-going vessels of considerable draught can proceed to Canton.

*Temperature and Rainfall.*—The monthly mean temperature exceeds 80°F. only during the four months June to September. During the months December to February it falls to about 60°F. The annual mean rainfall is about 65 inches, April to August being the rainy months.

*Water Supply.*—There is a public water supply of limited extent brought from the hills eight miles from the city, but both within and without the city walls there are large numbers of wells. The practice of storing water in jars is very general.

*Sanitation and Quarantine.*—In the Chinese city little is attempted in the way of sanitation as understood in Europe. The Municipality of Shameen (British Concession) employs a medical officer of health.



There is a quarantine anchorage down river from Canton, but there are no buildings or staff to deal with infected ships. The Medical Officer of Health, Shameen, has assigned to him by the Chinese Customs Department some duties in connexion with quarantine matters, but these duties appear to be ill-defined.

### Mosquitos.

(A). Adult mosquitos taken in houses:—*Culex fatigans*, *C. sitiens*, *Armigeres obturbans*, *Stegomyia albopicta* (*scutellaris*), *Anopheles sinensis*.

(B). Larvae from artificial collections of water:—*Culex fatigans*, *Stegomyia albopicta* (*scutellaris*), *Armigeres obturbans*.

(C). Larvae from natural collections of water:—*C. fatigans*.

The weather conditions were unfavourable for the development of mosquitos during the time of my visit. No *Stegomyia fasciata*, either larvae or adults, were found. *S. albopicta* larvae were present in fair numbers in jars both within and without the city, but their development was slow. Larvae of this species taken at Canton on 13th December 1915, which were apparently then half-grown, transformed to pupae on 6th January 1916 in Kuala Lumpur and a few adults hatched out 8th–10th January 1916.

Since my visit I have had sent to me collections of mosquitos taken in Canton during the month of March. Among these were no specimens of *Stegomyia*.

### Batavia.

Batavia, the principal city in West Java, is situated on the Bay of Batavia in latitude 6° 7' South and longitude 106° 48' East. It is a long narrow city extending along the banks of the river Tjiliwong and comprises the port (Tandjong Priok), the old town (Batavia), and the new town (Weltevreden). The population is about 138,000.

*Trade*.—Batavia has extensive trade relations with all the neighbouring ports and is the point of departure for lines of steamers to Australia, Europe, America (by way of the Philippine Islands) and Japan.

*Temperature and Rainfall*.—The annual mean temperature is about 79°F. The temperature is nearly the same throughout the year, the greatest difference between the highest and lowest monthly mean being only about 2°. The annual mean rainfall is 71 inches, October to April being the wet months.

*Water Supply*.—The public water supply is drawn from artesian wells and is distributed throughout the city by means of pipes to hydrants and private houses. From the hydrants water is carried in tins to the houses in the native quarters and is there stored in earthenware jars. There are also large numbers of open wells.

A scheme for a constant high pressure supply of water from the hills has been under consideration for some years.

*Sanitation and Quarantine*.—Special officers devote their whole time to sanitary work and important progress has been made during recent years in improving the condition of the native quarters of the city.

There is a special staff which devotes attention to anti-mosquito measures. Native assistants are taught to recognise the different kinds of larvae and to deal with breeding places. By means of posters in the vernacular languages, cinematograph films and lectures, the people are taught the importance of mosquito-borne diseases and the means of preventing them.

The quarantine station is situated on two islands in the Bay of Batavia about 6 miles from the town. It is supplied with ample accommodation to meet any emergency. There is a complete equipment of apparatus for disinfection.

### *Mosquitos.*

(A). Adult mosquitos taken in houses:—*Culex gelidus*, *C. tritaeniorhynchus*, Giles, *Stegomyia fasciata*, *Mansonioides annulipes*, *M. annuliferus*, *S. fasciata* var. *luciensis*, Theo., *Mansonioides uniformis*, *Culex fatigans*, *Armigeres obturbans*, *Stegomyia albopicta* (scutellaris), *Culex whitmorei*, Giles, *C. vishnui*, Theo., *Aëdomyia catasticta*, Knab, *Anopheles rossi* var. *indefinitus*, *A. sinensis*, *A. ludlowi*, Theo., *A. fuliginosus*, *Banksinella lineatopennis*, Ludl., *Uranotaenia campestris*, Leic., *Culex bitaeniorhynchus*, Theo., *Rachionotomyia aranoides*, Theo., *Lophoceratomyia barkeri*, Theo., *Culex fuscocephalus*, *Cyathomyia brevipalpis*.

(B). Larvae from artificial collections of water:—*Stegomyia fasciata*, *S. fasciata* var. *luciensis*, *Culex fatigans*, *Armigeres obturbans*, *S. albopicta* (scutellaris).

(C). Larvae from natural collections of water:—*Culex fatigans*, *C. vishnui*, *C. tritaeniorhynchus*, *Anopheles tessellatus*, *A. kochi*, *A. rossi* var. *indefinitus*, *A. sinensis*, *A. ludlowi*, *A. barbirostris*.

At the time of my visit to Batavia mosquitos were very numerous, as may be inferred from the large number of species recorded. *Stegomyia fasciata* was prevalent in all parts of the city. Special measures are in operation to reduce the numbers of mosquitos; the task, which is under highly competent direction, is a formidable one.

### **Samarang.**

Samarang, the principal port of Mid-Java, is situated on the north coast about midway between Batavia and Soerabaya, in latitude 7° 15' South and longitude 110° 38' East. The population is about 96,000.

*Trade.*—Samarang is the commercial centre of a very large agricultural district. There are rail connections to all points in Java and many steamships touch at this port on their way to Singapore, Australia, China, India, Europe and America.

*Temperature and Rainfall.*—The climate of Samarang resembles that of Batavia. The annual mean rainfall is 86 inches.

*Water Supply.*—The public water supply is drawn from the hills. It is a constant high pressure supply and is distributed over the whole area of the city.

*Sanitation and Quarantine.*—These are supervised by officers of the Civil Medical Service. Samarang is a second-class harbour and the quarantine station is not provided with its own apparatus for fumigation. A new quarantine station is projected.

There are no special measures in force directed against mosquitos.

*Mosquitos.*

(A). Adults taken in houses :—*Culex fatigans*, *Stegomyia fasciata*, *S. fasciata* var. *luciensis*, *Uranotaenia cancer*, *Anopheles ludlowi*, *C. tritaeniorhynchus*.

(B). Larvae from artificial collections of water :—*Stegomyia fasciata*, *S. fasciata* var. *luciensis*, *Culex fatigans*.

(C). Larvae from natural collections of water :—*Culex fatigans*, *C. bitaeniorhynchus*, *Anopheles ludlowi*, *A. barbirostris*.

At the time of my visit mosquitos were not numerous at Samarang and *Stegomyia fasciata* was rarely encountered in houses. Larvae of this species were found in jars used for storing water in houses. The admirable public water supply is, I think, an important factor in keeping down the numbers of mosquitos, which were less numerous than might have been expected.

Dr. W. T. De Vogel published in 1909 (Geneesk. Tijd. v. Ned. Ind. xlix, no. 5) an account of malaria infection experiments with Anopheline mosquitos bred from larvae taken in salt-water pools near the sea-coast at Samarang. These mosquitos were then identified as *Anopheles (Myzomyia) rossi*, Giles, and Dr. De Vogel's results gave rise to some controversy, as it had been thought that *A. rossi* was not a malaria-carrying species. During my visit to Samarang I re-examined these pools, but found in them only *Anopheles ludlowi*, Theo., and *A. barbirostris*, Wulp. At Soerabaia, however, in similar situations I took large numbers of larvae of *Anopheles rossi*, and I think it quite probable that Dr. De Vogel experimented with this latter species.

**Soerabaia.**

Soerabaia is situated on the Kali Mas and its tributary the Kali Pegirian in latitude 7° 14' South and longitude 112° 44' East. It is a long narrow city stretching along the banks of these rivers. Population 160,000.

*Trade.*—Soerabaia is the commercial metropolis of Java, and the greater part of the foreign trade is executed from this port. Regular steamship services are maintained with Makasser and other ports in Netherlands East Indies and with Australia, India and Europe.

*Temperature and Rainfall.*—The climate of Soerabaia resembles that of Batavia and other coast towns. The annual mean rainfall is 68 inches.

*Water Supply.*—The public water supply of Soerabaia comes from the hills. It is a constant high pressure supply and is distributed over the whole city.

Dr. J. T. Terburgh, Chief of the Public Health Service of East Java, has during several years studied the important question of supplying the native population with pure water at small cost. This problem, of vital importance from the point of view of water-borne diseases such as cholera, is also intimately connected with the question of *Stegomyia* reduction in sea-port towns. Dr. Terburgh was good enough to demonstrate to me the methods which he advocates and to show me their practical working in a native kampong of Soerabaia.

Water is brought to each house in pipes and by means of a permanent water-meter, devised by Dr. Terburgh, a quantity of water, estimated to be sufficient for drinking and domestic purposes, is delivered at a uniform rate. The water is stored

in cement reservoirs of appropriate capacity, whence it can be taken as required. Dr. Terburgh claims for his method that an adequate supply of water is delivered, that wastage is prevented, and that after making provision for interest on capital expenditure and for repayment, the cost to the consumer may be less than he now pays for the transport of water from hydrants.

Owing to the more or less constant disturbance of the water surface in these reservoirs there is less tendency for the female *Stegomyia fasciata* to lay eggs in them than in the common water-jar. Nevertheless larvae of this species were not uncommonly found in the reservoirs. It was observed also that despite the existence of an adequate supply of water at all times in the reservoir, the natives removed water from them and stored it in jars in accordance with a custom that obtains everywhere throughout Eastern countries.

In his experiments Dr. Terburgh had not in mind the question of the reduction of breeding places of *Stegomyia*, but I understand that he proposes to carry out further experiments in an endeavour to meet this indication also. I was much impressed by the possibilities revealed by Dr. Terburgh's proposals for the solution of the problem of mosquito control in the densely populated towns of the East.

*Sanitary Service and Quarantine.*—Special officers are in charge of these services and they are provided with subordinate staffs who are now being instructed in the details of anti-mosquito work.

A new quarantine station has been approved and is to be built on the island of Madura opposite Soerabaia.

### *Mosquitos.*

(A). Adults taken in houses :—*Culex fatigans*, *Stegomyia fasciata*, *S. fasciata* var. *luciensis*, *C. sitiens*, *C. vishnui*, *C. minimus*, *Anopheles rossi*, *A. rossi* var. *indefinitus*, *Culex bitaeniorhynchus*, *Anopheles barbirostris*.

(B). Larvae from artificial collections of water :—*S. fasciata*, *C. fatigans*.

(C). Larvae from the water collected in cut bamboos :—*S. albopicta* (*scutellaris*) ; *Rachionotomyia aranoides*.

(D). Larvae from natural collections of water :—*C. fatigans*, *C. vishnui*, *C. sitiens*, *C. bitaeniorhynchus*, *Anopheles rossi* var. *indefinitus*, *A. rossi*.

Mosquitos were numerous in Soerabaia and *S. fasciata* was a common species. The problem of their reduction is receiving special attention.

### **Makasser.**

Makasser, the capital of Celebes Island and its dependencies, is situated on the west coast of Southern Celebes in latitude 5° 20' South and longitude 119° 40' East. Population 26,000.

*Trade.*—Makasser is a trade centre for Eastern Netherlands East Indies and a port of call for steamships proceeding to Australia, Manila and Hong Kong.

*Temperature and Rainfall.*—The mean temperature is about 80°F. The climate is less equable than that of Java and the daily variation may be as much as 18°F. The annual mean rainfall is 115 inches.



*Water Supply.*—The water supply is drawn from surface wells in compounds. The question of a piped water supply has been mooted, but the expense involved is great.

*Sanitation and Quarantine.*—These services are supervised by the Military Medical Authorities. There are no special measures in force directed against mosquito breeding.

### *Mosquitos.*

(A). Adults taken in houses :—*Culex fatigans*, *Stegomyia fasciata*, *C. tritaeniorhynchus*, *C. vishnui*, *C. fuscocephalus*, *Anopheles rossi* var. *indefinitus*, *A. sinensis*, *A. barbirostris*.

(B). Larvae from artificial collections of water :—*Stegomyia fasciata*.

(C). Larvae from natural collections of water :—*C. fatigans*, *C. vishnui*, *A. rossi* var. *indefinitus*.

(D). Larvae in cut bamboos :—*S. albopicta* (*scutellaris*), *Rachionotomyia aranoioides*.

Mosquitos are exceedingly prevalent at Makasser and *Stegomyia fasciata* very numerous, but no special measures were in operation for their destruction. There were large numbers of mosquito larvae in the cement reservoirs used for storing water in bath-rooms.

### III. OTHER RECORDS OF STEGOMYIA.

During the course of this inquiry I have received a number of collections of mosquitos from different parts of the Malay Peninsula and neighbouring countries. Among these the new records of the occurrence of species of *Stegomyia* are as follows :—

#### 1. *Stegomyia fasciata*, F.

Malay Peninsula : Kelantan (Tumpat) ; Kedah (Alor Star) ; Pahang (Kuantan).  
Borneo : British North Borneo (Jesselton) ; Pulau Laut (Stagen).  
Java : Tegal ; Djokjakarta ; Tjilatjap ; Garoet ; Billiton I.  
Sumatra : Djambi ; Padang ; Indrapura ; Pulau Weh.  
Celebes : Boetan I. ; Soembawa I.  
New Guinea : Port Moresby.

#### 2. *Stegomyia albopicta*, Skuse.

Malay Peninsula : Kelantan ; Kedah ; Ginting Simpah, Selangor (2,000 ft.).  
Siam : Krabin ; Koh Chang I.  
Borneo : British North Borneo.  
Java : Djokjakarta ; Tjilatjap ; Billiton I. ; Lombok I.  
Celebes : Boetan I.  
Sumatra : Djambi ; Indrapura ; Padang ; Palambang.

#### 3. *Stegomyia variegata*, Dol.

New Guinea : Port Moresby.

#### 4. *Stegomyia fusca*, Leic.

Siam : Krabin ; Koh Chang I. ; Koh Mohsi I. ; Koh Kra I. ; Koh Klun I. ; Koh Rang I. ; Koh Kut I.  
Malay Peninsula : Kuala Lumpur.

5. *Stegomyia W-alba*, Theo.  
Malay Peninsula : Kuala Lumpur.  
Siam : Bangkok.  
Sumatra : Pulau Weh.
6. *Stegomyia trilineata*, Leic.  
Malay Peninsula : Ulu Gombak, Selangor.
7. *Stegomyia desmotes*, Giles.  
Malay Peninsula : Ulu Gombak, Selangor.
8. *Stegomyia albolineata*, Theo.  
Malay Peninsula : Kuala Lumpur.

#### IV. GENERAL REMARKS.

*Mosquitos on Ships.*—It was pertinent to the subject of my enquiry to endeavour to learn to what extent mosquitos were in fact conveyed on ship-board from port to port. In the course of this enquiry, I travelled on a number of ships, some of them of recent construction, some of them old. Careful examination was made in port and at sea. Once only was *Stegomyia fasciata* observed, and on that occasion the ship lay in a river on both banks of which this species was breeding in very large numbers.

*Occurrence of S. fasciata inland.*—It is often stated that in the East *S. fasciata* is found on land only near the sea coast. It is therefore of some importance to note its occurrence at inland points in Java and the Malay Peninsula. This species was taken at Garoet, in West Java, 40 miles from the sea and 2,300 feet above sea-level. Within the past ten years *S. fasciata* has replaced *S. albopicta* (*scutellaris*) as the common *Stegomyia* species in Kuala Lumpur, an inland town of the Malay Peninsula 27 miles from the sea.

*Trade Routes.*—The old trade routes between America and the Orient have been little affected by the opening of the Panama Canal to traffic. These routes still pass northward by way of Honolulu, Japan and China. There is little direct traffic within the tropical zone.

#### V. SUMMARY AND CONCLUSIONS.

1. In Far Eastern ports of the equatorial region the yellow fever carrier, *Stegomyia fasciata*, is prevalent at all seasons of the year. Even where efforts have been made to reduce its numbers it is common; where no such efforts have been made, it is a veritable plague.

In this region the conditions are highly favourable for the spread of yellow fever if it should once be introduced.

2. The old trade routes between America and the Orient have not so far been altered with the opening of the Panama Canal to traffic, these routes still pass northward by way of Honolulu, China and Japan. It was found in the course of this enquiry that in ports situated towards the northerly limit of the Eastern tropical belt *S. fasciata* occurred in relatively small numbers in the colder months or was not met with at all.

It is thought probable that a survey of the ports of China and Japan would show that the conditions there are unfavourable for the propagation of *S. fasciata* even in the warmer months.

If this supposition should prove correct it would be shown that the path for the conveyance of yellow fever infection to the Orient is cut at this point. It is therefore important that a survey of these ports should be undertaken in completion of the observations here recorded.

3. Systematic observations on a number of ships within the tropical belt failed to disclose the presence of *S. fasciata* on board ships at sea, even when coming from ports heavily infested with this mosquito. It is suggested that too much importance has hitherto been attached to the possibility of the conveyance of infected mosquitos over long distances in ships, and that with modern steel ships the danger is minimal.

4. With the prospective increase in sea-borne traffic it is more than ever imperative that measures for *Stegomyia* reduction in Far Eastern ports should be vigorously pursued. Examples of effective action are not wanting, and the work of James and his colleagues in Colombo has shown what may be accomplished in this direction.

5. Trained entomologists should be engaged to give their whole time to the study of the highly specialised problems connected with mosquito reduction and to the supervision of measures. These officers should work in close co-operation with the executive public health authorities.

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## COLLECTIONS RECEIVED.

The following collections were received by the Imperial Bureau of Entomology between 1st July and 30th September, 1919, and the thanks of the Managing Committee are tendered to the contributors for their kind assistance :—

Dr. W. Mansfield-Aders, Government Economic Biologist :— 6 Culicidae and 53 other Diptera ; from Zanzibar.

Capt. P. J. Barraud :—150 Culicidae, 4 *Phlebotomus*, 1 Hippoboscid, 20 other Diptera, 19 Hymenoptera, 32 Coleoptera, 7 Planipennia, 15 Lepidoptera, 11 Rhynchota, 7 Orthoptera, 1 Mayfly, and 17 Odonata ; from Palestine.

Mr. G. E. Bodkin, Government Economic Biologist :—7 Diptera, 1 Flea, 26 Termites, 160 Ants, 8 other Hymenoptera, 39 Coleoptera 4 Lepidoptera, 22 Rhynchota, 1 Grasshopper, 23 Ticks, 4 Millipedes, 1 Scorpion, and 3 Worms ; from British Guiana.

Dr. C. K. Brain :—A number of Chalcids ; from Surrey.

Capt. P. A. Buxton :—15 Culicidae, 1 *Tabanus*, 1 Hippoboscid, 12 Lepidoptera, and 10 Rhynchota ; from N. W. Persia.

Division of Entomology, Pretoria :—4 Hippoboscidae, 38 other Diptera, 12 Hymenoptera, 162 Coleoptera, 71 Rhynchota, and 20 Orthoptera ; from South Africa.

Mr. E. Melville Du Porte :—5 Coleoptera ; from Canada.

Durban Museum :—41 Coleoptera ; from Natal.

Dr. Eustace W. Ferguson :—17 Tabanidae : from New South Wales.

Dr. Lewis H. Gough, Government Entomologist :—3 Trypetid Diptera ; from Egypt.

The Government Entomologist, Madras :—113 Diptera, 12 Hymenoptera, 14 Coleoptera, 1 species of Coccidae, and 6 other Rhynchota ; from Southern India.

Mr. C. C. Gowdey, Government Entomologist :—56 Diptera, 1 tube of Braconid parasites, 110 other Hymenoptera, 70 Coleoptera, 11 Lepidoptera, 20 Rhynchota, 5 Orthoptera, and 2 Odonata ; from Uganda.

Mr. E. Hargreaves :—52 Culicidae, 5 Tabanidae, 1 Hippoboscid, 1 tube of Chalcids, 5 Coleoptera, and 4 Rhynchota ; from Italy.

Mr. William Harris, Government Botanist :—A species of Coccidae, and 41 Coleoptera associated with it ; from Jamaica.

Dr. C. Gordon Hewitt, Dominion Entomologist :—20 Psyllidae ; from Nova Scotia.

Mr. C. W. Hobley :—5 *Hematopota*, 9 *Tabanus*, 1 *Glossina*, and 1 Tachinid ; from British East Africa.

The Imperial Department of Agriculture, West Indies :—24 Melolonthid beetles, 11 larvae, and 11 pupae ; from Antigua, etc.

Mr. H. H. King, Government Entomologist :— 3 Culicidae, 1 *Chrysops*, 3 *Tabanus*, and 30 other Diptera ; from the Anglo-Egyptian Sudan.



Mr. A. Loveridge :— 30 *Glossina*, 449 other Diptera, 56 Dipterous larvae, 49 Dipterous pupae, 93 Fleas, 109 Thysanoptera, 1,471 Ants, 71 other Hymenoptera, 2,252 Coleoptera, 332 Coleopterous larvae, 93 Coleopterous pupae, 40 Lepidoptera, 179 Lepidopterous larvae, 12 Lepidopterous pupae, 2 Caddis-flies, 282 Termites, 9 species of Coccidae, 95 Cimicidae, 500 Aphididae, 852 other Rhynchota, 20 Odonate nymphs, 5 May-flies, 21 Mallophaga, 4 Anoplura, 29 Ticks, 400 Mites, 99 Spiders, 17 Scorpions, 3 Centipedes, 41 Millipedes, and 27 Worms ; from Portuguese and " German " East Africa.

Dr. R. E. McConnell :— 1 *Tabanus*, 30 other Diptera, and 4 Rhynchota ; from Uganda.

Dr. J. W. Scott Macfie :— 438 Culicidae, 104 *Phlebotomus*, 5 other Psychodidae, 17 Ceratopogoninae, 8 Cecidomyiidae, 2 *Tabanus*, a number of other Diptera, 7 Hymenoptera, 5 Coleoptera, 21 Lepidoptera, 20 Termites, 3 Rhynchota, 3 Orthoptera, and samples of grain attacked by insects ; from the Gold Coast.

Capt. Malcolm E. MacGregor :—54 *Anopheles maculipennis*, with a number of eggs ; from Kent.

Mr. Arthur W. J. Pomeroy, Government Entomologist, Nigeria :—17 Tabanidae, and 354 other Diptera ; from the United States of America : 24 Hippoboscidae, 35 other Diptera, 16 Chalcids, 57 other Hymenoptera, 287 Coleoptera, 72 Lepidoptera, 75 Rhynchota, 11 Orthoptera, and 15 Odonata ; from Southern Nigeria.

Dr. J. O. Shircore :—5 Diptera and 1 Bug ; from British East Africa.

Mrs. W. Smith :—19 Culicidae, 2 *Glossina*, 49 other Diptera, 11 Hymenoptera, 12 Coleoptera, 16 Rhynchota, and 9 Orthoptera ; from Kumasi, Gold Coast.

Dr. F. H. Storey :—181 Culicidae, 10 Tabanidae, 163 *Glossina*, and 30 other Diptera ; from Koforidua, Gold Coast.

Mr. C. F. M. Swynnerton :— 19 *Glossina* and their pupa cases, 3 other Diptera, and 6 Hymenoptera ; from Portuguese East Africa.

Mr. F. V. Theobald :— 1 Orthopteron ; from Mesopotamia.

Mr. R. Lowe Thompson :—113 Coleoptera ; from Southern Rhodesia.

Mr. F. W. Urich, Government Entomologist :—33 Culicidae, and 24 Mutillid Hymenoptera ; from Trinidad.

Mr. F. C. Willcocks, Entomologist to the Sultanic Agricultural Society :—24 slides of Mallophaga, Anoplura, and Acarina ; from Egypt.

Mr. C. B. Williams :—54 *Chrysops* and 45 *Tabanus* ; from Trinidad.

# INVESTIGATIONS INTO THE BIONOMICS OF *GLOSSINA PALPALIS*.

By W F. FISKE.

## INTRODUCTION AND GENERAL DISCUSSION.

These studies were made in Uganda on the islands and shores of Victoria Nyanza, in territory which had been depopulated some years before on account of tsetse-fly and sleeping sickness. They were begun in October 1913, and extended over two full years, of which eighteen months were spent in the fly belt on Victoria Nyanza, and three months on a tour into Bunyoro, where for the time being (the spring of 1914) *Glossina morsitans* was the centre of greater attraction as a possible vector of human trypanosomiasis. Seven tours were made from headquarters at Entebbe—the shortest, of three days only, being interrupted by the War, and the longest, of eight full months, being much prolonged by the War.

The working basis unquestioningly accepted in the beginning was that the measures adopted in 1906-07 for the suppression of sleeping sickness in Uganda were both wise and necessary. These measures called for complete severance of contact between the fly and the native populations so long as infection was present. They had contemplated originally the elimination of infection through complete severance of contact between fly and population, but in this particular had failed of their object, for the trypanosome persisted both within and without the depopulated zone; as a parasite of game and fly within it, and as a human parasite in the riparian populations of adjoining sectors of the lake region without it. They therefore required the extermination of fly in populated districts, or as a prerequisite to reclamation and repopulation of territory from which the inhabitants had been removed. They were exactly such measures as are absolutely required for suppression and prevention of the cattle trypanosomiasis transmitted by *Glossina morsitans* in other parts of Uganda; and going on the perfectly natural assumption that a close parallel existed between human and bovine trypanosomiasis, as transmitted by *Glossina palpalis* and *Glossina morsitans*, respectively, the wisdom and necessity of the measures was not questioned.

The economic or practical objective of the studies was the sanitation and reclamation of the fly-infested territory; the more immediate and technical objective, therefore (proceeding on the above assumption), was the extermination of fly as a sanitary prerequisite to reclamation. To exterminate a species is to restrict its range or distribution. Therefore, the most immediate objective was made that of identifying and studying those factors in the bionomics or "control" of the species which operate in nature, or which might be operated by artifice, to delimit and determine or to "control" its range.

It was an integral and most important feature of the original plan that, after the factors which operate in the "natural control" of the insect should have been identified and studied, an experiment should be conducted on a "practical" scale to demonstrate at the same time the accuracy and the economic applicability of the knowledge acquired. By the spring of 1915 sufficiently definite conclusions had been reached on the particular points at issue to justify this experiment. Until then the investigations had been conducted on the islands. The experiment could not be made on the islands, but must be made on the mainland. Consultation with the Principal Medical Officer as to the best site for it led to the selection of the Buddu district, which borders the lake for some ninety miles just north of the old German frontier. Therefore a tour was made with the object of surveying this reach of shore carefully, to ascertain the degree of infestation by the tsetse; the probable cost of exterminating it; the precise location of old village sites, canoe landings, fishing grounds, etc., with respect to fly; and such other points as required consideration preliminary to any experiment of the character proposed.

The results of this survey were unexpected, and led to a complete revolution of ideas previously entertained. The reach of shore is naturally divided into a considerable number of semi-isolated districts, having from two and a half to seventeen miles of frontage on the lake. Some of these districts were found to be infested by tsetse to a degree of density never before encountered. Others were very lightly infested. In one district a few days labour with a good gang of men would have sufficed to exterminate all the fly on a reach of some five miles. In this case the natives would very willingly have given the labour in return for the lands and the fishing grounds off shore, for the lands were good and extensive and the fishing grounds productive. In several other districts it was thought probable that the value of the land and water rights was sufficient to induce the natives to undertake all the labour requisite to exterminate fly without other expense to the Government than that of supervision and inspection. Any of these would have been an excellent site for the proposed experiment.

There was one district, however, Bukakata, which had a frontage of some six and a half miles on the lake and included the steamer landing for Masaka station, that presented a strange problem. The lands adjoining the lake in the depopulated or forbidden zone were valueless for agriculture. The fishing rights were valuable, and would have been a considerable inducement to the natives to clear the shore of tsetse, except for the fact that the natives were already occupying them, openly, for the entire reach of six miles. Infestation by tsetse was much heavier than in certain other districts, but still moderate, exceeding the average for the lake shore and islands as a whole at only a few points, and averaging for the district about half the average for the region generally. Careful inquiry failed to elicit a particle of evidence that any of the native fishermen had suffered in the slightest degree from long-continued exposure to tsetse under these conditions.

At certain other points along the shore surveyed poaching was free and flagrant; at one point in particular, where density of fly was more than seven times greater than the average for the region generally, and where, in addition to this, food (of fly) was very scarce and the flies literally ravenous, twenty-three fish traps,

some new and some old and discarded, were found along a two-mile reach of shore, indicating regular and long-continued contact between trespassers and fly at its very worst. Less aggravated conditions were frequently encountered along many reaches of mainland shore.

On returning to Entebbe a special survey was made for fly within the inhabited precincts and for trespassing by natives beyond them. It was found that a considerable portion of the township was very lightly, but constantly or regularly, infested by fly (to an easily measurable degree), and that at certain points in the environs natives went freely into contact with fly at a moderate—but nowhere excessive—degree of density. Similar conditions prevailed at Jinja and at Kampala, the two other lake ports.

With these conditions in mind, inquiry was made concerning the number of cases of sleeping sickness recorded in the official death returns or coming to the attention of Medical Officers; for it was thought certain that some must occur. To my very great surprise I learned that, so far as known, not a single case had been contracted within the Province of Buganda—for which the returns are most reliable—since 1912, and that with the exception of two cases (one of them not surely trypanosomiasis, and the other possibly contracted in Busoga) among the men who accompanied Dr. G. D. H. Carpenter on his tour to the islands in 1911–12, no cases were known or suspected to have been contracted since the islands were depopulated in 1909.

A curious situation was thus created, which led to the abandonment of the proposed experiment and to complete readjustment of ideas and preconceptions. In theory—the theory upon which the suppressive and preventive measures had been based—complete severance of contact between fly and population was necessary in order to control sleeping sickness, but in actual practice complete severance of contact was found to be unnecessary. In theory it was necessary either to exterminate fly from populated districts or to make removal of inhabitants “from the vicinity of tsetse complete and without exception”; but in practice it was proved sufficient to reduce the density of fly to within moderate limits in populated districts or to reduce density of population to within moderate limits in fly-infested territory.

If this is really sufficient, knowledge concerning factors which control range of the insect is more or less superfluous, whereas knowledge of factors which operate to control breadth of contact between fly and population—equivalent to frequency of contact between hungry flies and men—is specifically required.

Two very different lines of study are thus outlined. Which of them ought to be followed?

As a matter of fact, both were followed: the first up to 1915, and the second during the last months of field work. One of them was impractical, and the specific results of it are practically valueless, except as disjointed fragments of information gained can be salvaged for use in other connexions. Which of these two lines of investigation ought to be reported upon?

In the accompanying manuscript neither has been reported upon, because this question has not been answered, nor any specific object for the preparation of any



report defined. It contains a mere mass of unapplied, and for the present inapplicable, information of no practical value until a decision has been reached on the following points:—

- (1) Shall the original plan for these investigations be followed, and an experiment be planned and conducted to test the accuracy and applicability of the conclusions reached?
- (2) If so, shall the object be—
  - (a) to exterminate fly and prevent all contact between fly and population, in accordance with the theories held in 1906–07; or
  - (b) to reduce excessive density of fly and to prevent excessive breadth of contact between fly and population, in accordance with present practice—as in the Bukakata District in 1915–16?

Unfortunately the decision cannot rest on the results of these studies in tsetse bionomics, which have only the most indirect bearing upon the point at issue. Every bit of information which seemed, even remotely, to bear upon them, and which could be gleaned from any available source, was included in a report presented in 1916, upon which no action has been taken at this date of writing. The one phase of tsetse bionomics having any bearing on these points is the fly's choice of hosts and host preferences. This is enlarged upon in the following pages.

The methods used in conducting these studies consisted in the main of a "fly survey" of the lake shore and islands. This survey was designed to measure as accurately as possible all peculiarities and variations in the range of the insect, and all variations in its density as they occurred from time to time in the same localities, or from one locality to another at the same time. Coincidentally observations were made and notes kept concerning every factor known or suspected to operate in the "natural control" of range and density, with the object of identifying those of major importance, *i.e.*, such as are responsible for easily measurable peculiarities in range or variations in density. No attempt was made to study specific factors—such as natural enemies—unless they were indicated to be of sufficient importance to account for measurable variations in density. By this procedure much useless work was avoided.

These methods were especially applicable to studies having as their ultimate or practical objective the extermination of the insect. But after the readjustment of old ideas and preconceptions of the economic problem, made necessary by the discovery that it is practically unnecessary, and even, for economic reasons, undesirable to undertake extermination of fly, entirely different methods of study were demanded. The questions to be answered involved less the range and density of tsetse and the factors controlling them than the injuriousness of the tsetse and the factors in its control. The injuriousness of the insect, or its injurious status in relation to a population occupying the same or adjoining territory, is, in part, but only in relatively small part, determined by density of infestation. Factors of equal or even greater importance are those which control the frequency of contact between flies and persons, and these include the relative abundance of host animals (such as crocodiles), the principal occupations of the population, the precise location of points of occupation or concourse of the population with respect to colony centres

of fly, and various others to which the original fly surveys had accorded only incidental attention or had left out of consideration entirely. Reduction in density of fly is one object; reduction in the injuriousness or injurious status of fly is, in actuality, a totally different object, and methods of study must vary accordingly.

Finally, it was disclosed that the question of paramount importance was one that required yet different methods of study. It is to define the extent to which frequency of contact between flies and persons inhabiting a given region must be reduced in order to bring human trypanosomiasis under effective and satisfactory control. It is a question which can only be answered by measuring the frequency of contact and the coincidence of trypanosome infection in the population. It is, I regret to say, impossible for me to carry on investigations along this most necessary line unaided. It is for the entomologist to measure density of fly and frequency of contact between flies and men, and to identify and study the factors in control, but unless he is specifically trained to diagnose and detect trypanosome infection, his studies are incomplete and of relatively little value.

Every effort was made in 1915 to secure the co-operation of a Medical Officer for a tour along the coast and islands of Nyanza Province (British East Africa), where the riparian populations had not been removed; but, on account of the War, nothing could be done. Some little information on this point was gleaned from old (manuscript) reports of Medical Officers employed on "Sleeping Sickness Extended Investigations" in Uganda, which, as far as it went, strongly confirmed the presumption that the disease is incapable of spreading unless there is excessive breadth of contact between fly and population—in excess, for example, of that encountered in the survey of the Buddu shore in the Bukakata District—and a few other scraps of information have been found in literature—for example, in Todd and Wolbach's survey for human trypanosomiasis in the Gambia, which contains a few brief references to prevailing density of fly and frequency of contact—but it is a line of investigation which has yet to be systematically followed.

#### I. DISPARITY BETWEEN THE SEXES OF *GLOSSINA PALPALIS*.

When any considerable number of flies of this species of *Glossina* are caught, it is unusual to find the sexes evenly represented. Although they are produced in equal or approximately equal numbers, they are caught in unequal numbers.\*

This disparity between the sexes of *Glossina palpalis* is an extremely variable quantity, ranging in different localities (in catches of 100 flies or more) from 1.9 per cent. to 85.0 per cent. of females or from 15.0 per cent. to 98.1 per cent. of males. Females never predominate to quite the extent of males, and most frequently the males are in excess.

Various hypothetical explanations for this phenomenon have been proposed by Medical Officers and Entomologists who have observed it, and prior to the inception of these investigations all these explanations presupposed that "caught flies are hungry flies" (attracted to their captor through desire to feed on his person), therefore

\* "Thus of 1,400 flies bred from pupae obtained on Damba Island the proportions were ♂:♀:: 48:52. Whereas of 5,000 flies caught during the period in which the pupae were collected the proportions were ♂:♀:: 78.6:21.4." Carpenter: Repts. of the S.S. Comm. of the Royal Soc., xii, p. 105.

that the ratio between the sexes in the catch would be an index to the ratio actually existing between all flies in the locality or district where the catch was made. The deduction is logical from every point of view

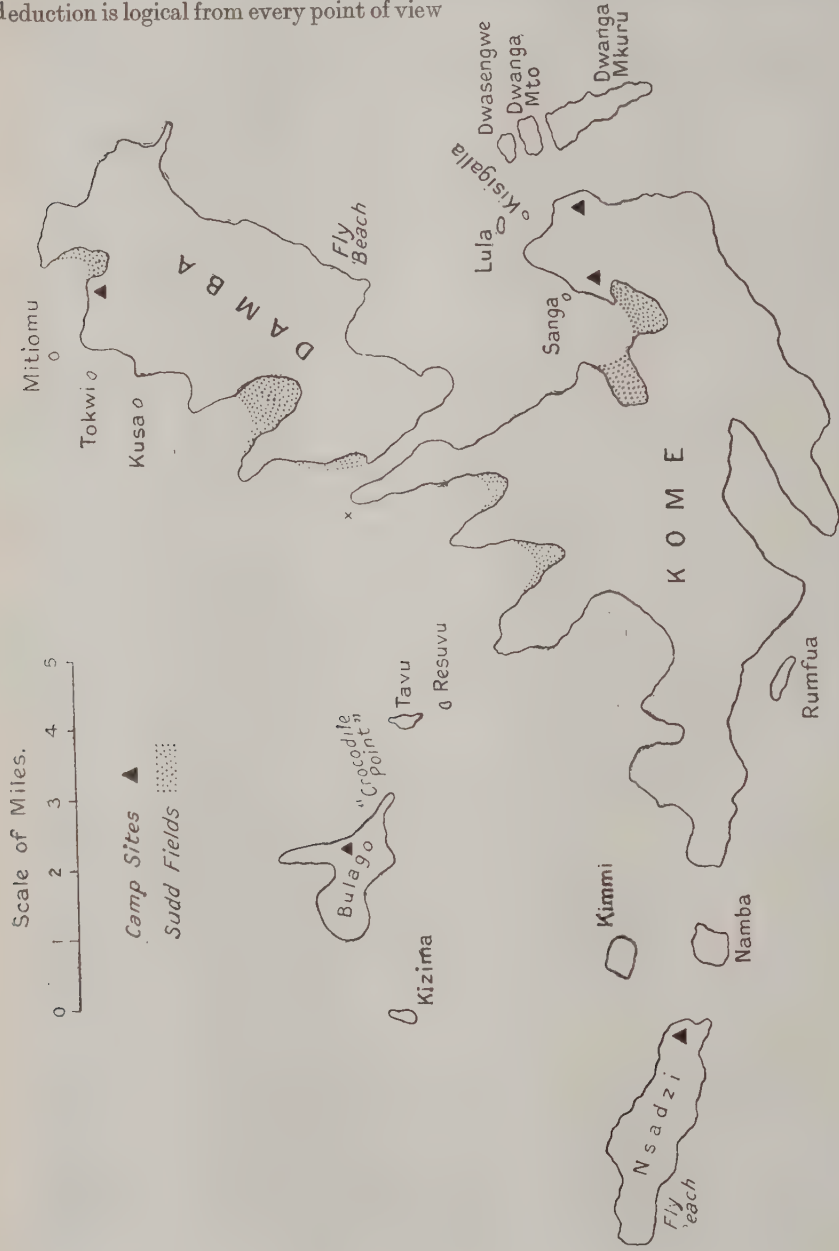


Fig. 1. Sketch-map of the Kone-Damba Group of the Sesse Islands.

But what becomes of the surplus males in localities where females predominate, or of surplus females, when, as usually is the case, males predominate, were questions that had not been answered when these investigations were begun. Whatever the explanation might be, it was certain to be intimately involved with phases in the bionomics of tsetse the nature of which could only be guessed, but the importance of which could not be doubted.

A minor problem was thus defined which served as a starting point for further investigations into the broad and complicated subject of the bionomics of *Glossina palpalis*, and the first field-work done was the series of experiments an account of which follows.

**I(a). Experiment to determine if Variations in Sex Ratio of *Glossina palpalis* are due to differences in the purely local, or in the climatic or seasonal Conditions of Life.**

The Islands of Bulago and Tavu (fig. 1) are separated by only a few thousand yards. Tavu is much the smaller and differs also in topography and vegetation. But the two islands are so near together that any difference in sex ratio, if constant and if occurring at the same seasons of the year, would necessarily be due to purely local conditions.

Large collections of fly were made on the two islands as shown in Table I. There was considerable variation in sex ratio observed on Bulago on different days (when collections were made at different points on the island), but in the total catch of 4,405 flies there were proportionately twice as many females as in the total catch of 3,126 flies from Tavu. This difference could only be attributed to purely local differences in conditions of life between these two islands.

TABLE I.

*Catch of Fly from Bulago and Tavu Islands, showing relatively constant difference in Sex Ratio.*

1913.	Island.	Daily Catch.		Total Catch.	
		Total.	Females.	Total.	Females.
1st Nov. ..	Bulago ..	170	35 %	170	35 %
2nd " ..	" ..	18	17 %	188	33 %
3rd " ..	" ..	60	24 %	248	32 %
4th " ..	" ..	630	25 %	878	28 %
5th " ..	" ..	564	27 %	1442	27 %
6th " ..	" ..	656	18 %	2098	25 %
" " ..	" ..	651	20 %	2749	24 %
10th " ..	" ..	" ..	27 %	3803	24.5 %
11th " ..	" ..	1057	27 %	3970	24 %
12th " ..	" ..	167	18 %	4405	25 %
13th " ..	" ..	435	29 %	" ..	" ..
5th " ..	Tavu ..	136	4 %	136	4 %
6th " ..	" ..	1179	8.3 %	1315	7.8 %
7th " ..	" ..	945	18 %	2260	12 %
8th " ..	" ..	866	13 %	3126	12.4 %



Much wider variations in sex ratio between different islands were subsequently noted, and the extremes are given in Table II. In all such cases—or at least in most of them—explanations for variations in sex ratio must be found in the purely local conditions of life, and not in climatic or seasonal differences.

The absolute extremes encountered in the course of the investigations, together with the records for all colonies of fly or infected districts in which female percentage exceeded 45.0 are presented in Tables III and IV.

TABLE II.

*Extreme Range in Variation of Sex Ratio (observed) between different Islands in Victoria Nyanza.*

Island.	Date.	Catch of Fly.	
		Total.	Females.
Kimmi .. .. .	January 1914 .. .. .	7065	63.5 %
Luambu .. .. .	July 1915 .. .. .	557	44.3 %
Wema .. .. .	February 1914 .. .. .	1413	39.1 %
Bugovu .. .. .	March 1915 .. .. .	415	39.0 %
Ngamba .. .. .	January 1914 .. .. .	761	7.9 %
Bugabu .. .. .	August 1914 .. .. .	704	7.9 %
Mbugwe .. .. .	September 1914 .. .. .	73	4.1 %
Nkase .. .. .	February 1915 .. .. .	101	3.0 %

TABLE III.

*Absolute Extremes in Sex Ratio as encountered in course of these Investigations on Islands and Mainland.*

Locality.	Date.	Catch.	Per cent. Fem.	Remarks.
Manene Island..	March 1915..	46	0.0	Largest catch with no females.
Bugaba Beach..	August 1914..	106	1.9	) Lowest percentage of females in catch of over 100 flies.
Manene Island..	March 1915..	107	1.9	
Bukakata ..	July 1915..	30	90.0	Largest percentage of females in catch of over 10 flies.
Bale Beach ..	June 1915..	241	84.6	Largest percentage of females in catch of over 100 flies

TABLE IV.

*Catch in those Districts on Mainland where Female Percentage averaged 45.0 or over for entire District.*

District.	Date.	Catch.	Percentage of Females.
Mujuzi Creek Colony, Buddu .. .. .	June 1915..	1611	67.6
Bukakata South Colony, Buddu .. .. .	July 1915..	298	51.0
Kaziru District, Buddu .. .. .	July 1915..	991	50.6
Kitebo District, Mawakotu .. .. .	August 1915..	1199	47.5
Gwamba District, South Buddu .. .. .	July 1915..	3422	45.0

### I(b). Relative Inactivity of Females of *Glossina palpalis* as the Explanation of Low Female Percentage in Catch.

The figures of the catches of fly from Bulago and Tavu Islands presented in Table I show a discrepancy in that the percentage of females in the total catch from Bulago Island tended to fall as the total grew, whereas on Tavu it rose sharply. This might be accidental, but the circumstances under which the experiment was conducted indicated otherwise. Tavu Island is much smaller than Bulago, and the catching of some 1,300 flies on the 5th and 6th of November seemed to have reduced the local density of the species appreciably, as measured by the average number of flies which could be caught per boy per hour. A corps of 9 or 10 boys was employed. During these first days of the investigations the exact time spent in catching was not recorded. It was approximately known, however, and when the catch of males and females per boy per hour (approximately) is tabulated it stands as in Table V.

TABLE V.

*Reduction in Density of Glossina palpalis on Tavu Island due to catching of Fly.*

1913.	Catch of Fly.		"Boy Hours."	Density of Fly Indicated.		
	Males.	Females.		Males.	Females.	Total.
6th November ..	1081	98	36	30.0	2.7	32.7
7th     "     ..	734	169	45	16.3	3.7	20.0
8th     "     ..	698	111	45	15.1	2.5	17.6

TABLE VI.

*Catch of Glossina palpalis on Lula Islet, showing the relative Inactivity of Females.*

Period (November 1913).	Catch for Period.			Catch to end of Period.	
	Males.	Fe- males.	Female Ratio.	Total.	Females.
18th Afternoon ..	280	18	6.0 %	298	6.0 %
19th Morning ..	308	72	19.0 %	678	13.3 %
19th Afternoon ..	93	68	42.2 %	839	18.8 %
20th Morning ..	83	146	64.3 %	1068	28.5 %
20th Afternoon ..	36	89	71.2 %	1193	32.9 %
21st All Day ..	95	224	70.2 %	1512	40.8 %
22nd     "     ..	51	79	60.8 %	1642	42.4 %
24th     "     ..	29*	73	71.5 %	1744	43.5 %
25th     "     ..	28*	93	76.9 %	1865	46.2 %
26th     "     ..	29*	65	69.1 %	1959	47.3 %
27th Morning ..	17	53	75.7 %	2029	48.3 %

\*These figures, apparently, represent about the daily emergence of males from pupae; all the old flies of this sex appear to have been caught off.

These data indicate that whereas the density of male flies had been reduced from 30.0 caught per boy per hour on the 6th to 15.1 on the 8th, that of female flies had not been appreciably reduced—exactly as though the females were actually present on the island but for some reason not so easily caught as either (a) the males on the same island, or (b) the females on Bulago Island (Table I).

This hypothetical explanation for a low percentage of females in the catch suggested the experiment of catching all the flies from an islet. Tavu was rather larger than convenient and the yet smaller islet of Lula (Fig. I) with an area of hardly more than 10,000 square yards was selected.

The results of this experiment are presented in Table VI. It was not carried to a final conclusion because of the time which would be required to catch all the flies emerging from pupae on the island (at least three weeks longer than the period devoted to it), but it was carried far enough to demonstrate conclusively that a very low percentage of females may be due to the relative inactivity, and not, as had always been assumed, to the absence of the sex.

#### I (c). The Percentage of Females among caught Flies as an Index to Food Supply.

An analysis of the data presented (in part) in Table VI and secured during the course of the Lula experiment above described disclosed the curious fact that although the catch of males fell sharply from 14.0 per boy per hour on the the first day to 2.6 and 1.7 on the morning and afternoon of the third day (see Table VII); that of females rose strikingly from .9 per boy per hour on the first to 4.5 and 4.4 on the morning and afternoon of the third day. Otherwise stated, the density of active male flies was quickly and permanently reduced to one-eighth or less of the original, but that of active female flies actually increased by no less than five times during the same period that that of the males was being reduced by seven-eighths.

TABLE VII.

*Analysis of Catch of Fly made on Lula Islet showing Variation in Activity of Females.*

Period (November 1913).	Density* of Active Flies.		
	Males.	Females.	Total.
18th Afternoon . . . . .	14.0	.9	14.9
19th Morning . . . . .	9.7	2.2	11.9
19th Afternoon . . . . .	3.5	2.8	6.3
20th Morning . . . . .	2.6	4.5	7.1
20th Afternoon . . . . .	1.7	4.4	6.1
21st All Day . . . . .	1.8	4.1	5.9
22nd " . . . . .	1.0	1.6	2.6
24th " . . . . .	.7	1.7	2.4
25th " . . . . .	.9	2.9	3.8
26th " . . . . .	.7	1.4	2.1
27th Morning . . . . .	.6	1.6	2.2

\* By "density" is meant the number of flies which can be caught per boy per hour.

This strange increase in the activity of the female flies on this islet was obviously associated with the experiment being conducted there, and that which seemed the most plausible explanation was that the male flies are normally active and easily caught at all times during good weather, whether they are hungry or not, but that the females are normally inactive and not to be caught except when hungry and seeking food. This hypothesis was borne out by the observation (made during the course of the experiment) that the mere presence of the corps of fly boys (9 or 10 of them) on the islet had temporarily banished from it the several crocodiles and *Varanus* which had formerly frequented it and which were the only visible sources of food for the flies. Assuming that only hungry females are active and easily caught, the effect of this would be to increase the number of them and therefore the number caught per boy per hour, through decreasing their food supply.

On this hypothesis such variations in the percentage of females amongst caught flies as are presented in Tables I and II (*i.e.*, such as occur between different islands) would indicate corresponding variations in abundance of food, or density of host animals. It was resolved to test this hypothesis by banishing the host animals from a small islet without catching off any of the flies, and observing the effect on sex ratio.

This experiment was made on the small island of Lugazi, in the following manner and with the following results.

19th and 20th December 1913. A total of 197 flies were caught on the islet, the sex was determined and they were then liberated (in order that catching off of males should not affect the sex ratio). The ratio was, males : females : : 166 : 31 = 15.5 per cent. females.

22nd to 27th December 1913. All host animals known to be fed upon by *Glossina*, consisting of several *Varanus* and crocodiles, were systematically hunted from the islet.

26th and 27th December 1913. A total of 208 flies were caught, showing sex ratio, males : females : : 89 : 119 = 57.2 per cent. females.

This experiment was carefully conducted, and careful notes were kept upon the behaviour of the flies on the islet towards man and also towards certain domestic animals which were tethered there (see Sect. II (b)). They were so strikingly affected by the banishment of their reptilian hosts as to leave no doubt that they had been principally dependent on them, and that the increase in percentage of females from 15.5 to 57.2 was the direct result of food shortage. Data on this phase of the experiment appear in Sect. II following.

#### I (d). The Real Ratio between the Sexes of *Glossina palpalis*.

The foregoing observations and experiments demonstrate conclusively enough that the ratio between the sexes of caught flies is no criterion of the real sex ratio in the locality where the catch is made. It would be impossible to determine the real ratio accurately, otherwise than by the continuation of such an experiment as was made on Lula until all flies had been caught, and this would require more time than the knowledge is likely to be worth.



It is believed, however, that the ratio in the catch on Lugazi after the hosts had been banished from the island (57·2 per cent. of females) is not far from representing the real ratio between the sexes on that particular islet. The more active males pretty certainly run greater risks, and do not on the average live so long as the less active females, and the real sex ratio would be determined by respective longevity of the sexes—probably a variable quantity.

An explanation is thus provided for any ratio between the sexes of caught flies from, say, 60 per cent. to 70 per cent. of females down, but doubtfully for female percentages of 70, 80 or even 90, such as are occasionally encountered. The explanation for these excessively high percentages was a mystery until long after the conclusion of the Lugazi experiment, when investigations into the movements of flies along the shore of a lake or stream provided the explanation (see Sect. III) and at the same time additional confirmation of the conclusions, tentatively reached through the Lugazi experiment, that the percentage of females in caught flies may serve as an index to the abundance of food (or density of host-animals) in the region where the catch is made. This conclusion is undoubtedly correct, provided that the catch is truly representative of the district or region; it is not correct if the catch is made under specific conditions (with respect to shelter, etc.) described in Sect. III.

## II. THE VARIABLE BEHAVIOUR OF *GLOSSINA PALPALIS* TOWARDS MAN AND DOMESTIC ANIMALS AS CORRELATED WITH VARIATIONS IN SEX RATIO.

The conclusions tentatively reached through the foregoing experiments are of interest in a vital connection. They suggest that if the female percentage is low, food must be plentiful, and man would be less liable to attack. Moreover, when a great majority of the flies are feeding regularly on reptilian hosts—which do not carry the virus of the human disease—many flies, or a dense infestation by fly, would be less injurious to man and less liable to transmit disease from man to man than if there were only a few flies, or a light infestation, feeding principally or exclusively on man, or on animals which may carry the virus of human disease.

Therefore, if the conclusions are correct, the injuriousness of *Glossina palpalis* to a population living in constant contact with it would be subject to variations independently of any variations in density of the fly, or of any other factor than the abundance of host animals incapable of harbouring the virus of human disease, and if it were attempted to reduce the density of fly, with the object of minimising its injuriousness, through measures directed against its host animals, the results might be the opposite of those desired. Through a campaign of extermination directed against its reptilian host, its density might be reduced, but its injuriousness increased.

Several experiments were conducted and many observations were made which have a bearing on the point, and which were also designed to confirm the conclusions to the Lula and Lugazi experiments cited above; for if these conclusions are correct, there must be a conspicuous correlation between variations in female percentage and in the persistency with which tsetse-flies press their attacks upon man.

In part, these experiments and observations are cited in this immediate connection (as confirmatory of the preceding conclusion); but they are further cited in subsequent pages in other connections.

## II (a). Methods used for Estimating the Density and Economic Status of *Glossina palpalis*.

The most convenient method for measuring variations in the density of *Glossina palpalis* is that of employing expert "fly boys" and of counting the number of flies which can be caught per boy per hour under standardised conditions. This method had already been used by Dr. G. D. H. Carpenter and others, and when care was taken to eliminate sources of error very reliable figures were secured.\*

On account of the very variable activity of the females it is obvious that estimates of local density must be based on the catch of males. That of females is of little significance by itself in indicating density, but taken in connection with the catch of males it possesses a large significance, and is indicative of variations in the economic status of the fly. This, like density, varies extremely (a) from time to time in the same region or locality, and (b) from one district or locality to another at the same time. It is in part determined by the density of fly, and variations in density correspond to variations in economic status (*i.e.*, by reducing density we assume that we depreciate the injurious status of the insect, and its status must naturally vary with natural fluctuations in density); but in larger part it is determined by the behaviour of the fly towards man, and this in turn by abundance of wild hosts. The female percentage is an index to abundance of hosts, and therefore to the liability of man to attack.

To illustrate the above, two extremes cited in Table III may be used: the infestations as measured in Bugaba and Bale beaches respectively. In each case the actual catches of fly were made at three points a few hundred yards apart on these beaches, and the complete data concerning degree of infestation are presented in Table VIII.

At first glance, in comparing the density of fly at these two points on the basis of the total catch—both sexes—per boy per hour, it would appear that there were twice as many flies along the Bale as along the Bugaba beach, for the total catch is more than twice as great. But the difference is very largely due to the enormously greater activity of the females at Bale, and if allowance is made for as many, proportionately to the males, at Bugaba as at Bale, it appears that there are almost three times as many fly at Bugaba, instead of less than half as many.

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\* Proper attention to the following suggestions will serve to eliminate various possibilities of error:—

- (1) Boys should be trained at least one month; all new boys in a corps without one or two experts as teachers would require longer training.
- (2) Nets must have a standard-sized ring and a standard length of handle; an 8-inch ring and 18-inch handle were used.
- (3) Catches should not be made before 8.30 or 9 a.m. nor later than 2.30 or 3 p.m.
- (4) Boys will make more even catches if provided each with a dark-coloured umbrella, upon which the flies will settle, and from which they are easily caught.
- (5) Unless density is very low—less than 1.0—it is better not to spend more than 2 to 3 "boy hours" at the same point on the same day; density is easily reduced, temporarily, by catching.
- (6) Boys should be stationed along the routes most likely to be followed by moving flies, and always, if there is shadow, at the edge of it.
- (7) Estimates of density must be based on catch of males, on account of the variability of female activity.
- (8) Good results cannot be secured on cool, cloudy or windy days.

TABLE VIII.

*Extremes of Variations in Economic Status of Glossina palpalis as indicated by Female Percentage.*

Locality and Point.	Catch of Fly.			No. of "Boy Hours."	Indicated Density.			Female Ratio.
	Males.	Fe-males.	Total.		Males.	Females.	Total.	
Bugaba—Pt. 15..	33	1	34	3	11·0	·3	11·3	3·0 %
" 16..	39	1	40	1½	26·0	·6	26·6	2·5 %
" 17..	32	0	32	1½	21·3	·0	21·3	·0 %
Bale—Pt. 49 ..	20	84	104	2	10·0	42·0	52·0	80·8 %
" 50 ..	10	80	90	2	5·0	40·0	45·0	88·8 %
" 51 ..	7	40	47	2	3·5	20·0	23·5	85·1 %
Totals—Bugaba..	104	2	106	6	17·3	·3	17·7	1·9 %
" Bale ..	37	204	241	6	6·2	34·0	40·2	84·6 %

It is also necessary to take account of the reason for the excessive activity of female flies at Bale. If this is caused by scarcity of food, it appears that all the females, and obviously the males as well, must be hunting for food. Therefore a man fishing on the beach would be likely to encounter no less than 40 hungry flies per hour.

But at Bugaba there would be only one hungry female each three hours, and if the males are proportionately hungry, not more than two flies that were actively seeking food would be encountered each three hours by the fisherman. This would indicate that the fisherman on Bale beach would be exposed to 60 food-hunting flies to 1 for the fisherman at Bugaba; *i.e.*, the fly at Bale, though less numerous by half, is indicated to be 60-fold more dangerous to a population living in contact with it than the fly at Bugaba.

This point seemed so important that confirmation of conclusions tentatively deduced by the above method was sought in various ways, and the final conclusions are that the fly really varies in economic status over a much wider range than as above indicated. There are several reasons for making this the final conclusion which need not be gone into; the point upon which evidence is submitted in the pages immediately following is that of the much greater freedom with which fly attacks man when the female percentage (for a district or region) is high than when it is low.

## II (b). Correlation between High Percentage of Females, artificially produced, and Persistence of Attack upon Man.

In the course of the Lugazi experiment to which reference has already been made (p. 357), two adult goats and one—subsequently another—small pig (of European stock) were tethered, equally exposed to attack by *Glossina*, along the shores of the island. From the 15th to the 20th of December great care was taken not to disturb the wild hosts of the fly on this islet. The female percentage taken on the 19th and 20th was found to be 15·5, which was probably maintained throughout this period.

From the 22nd December the wild hosts (crocodile and *Varanus*) were systematically hunted from the island. The effect on the behaviour of fly toward the tethered host animals was not noticeable on the first day, but appeared on the second in the increased number engorging upon them. The third day was overcast and flies were inactive, but on the fourth day, as may be seen from Table IX, a very notable increase in the number of flies engorging was brought about.

The percentage of females was determined anew on the 26th and 27th, and was found to have increased from 15.5 to 57.2. This was certainly due to decrease in number of wild hosts; the increase in number of flies engorging upon domestic animals was certainly due to the same cause, and is thus directly correlated with variations in sex ratio.

TABLE IX.

*Showing Effect of hunting Wild Hosts from Lugazi Islet upon Behaviour of Glossina palpalis toward Goat and Pig.*

Conditions on Islet.	Date (1913).	Pig.			Goat.		
		Hours ex- posed.	Flies engorg- ing.	Bites per Hour.	Hours ex- posed.	Flies engorg- ing.	Bites per Hour.
Wild hosts undisturbed. Female ratio 15.5 %.	15th December	—	—	—	9½	—	—
	16th "	—	—	—	2	—	—
	17th "	4	—	—	8	—	—
	18th "	3¾	—	—	7½	—	—
	19th "	8	1	.12	16	—	—
	20th "	8	—	—	16	—	—
Wild hosts hunted. Female ratio increasing to 57.2 %.	22nd "	8½	—	—	17	—	—
	23rd "	18	5	.28	18	3	.17
	24th "	17	4	.24	17	2	.12
	25th "	18	49	2.72	18	6	.33

The behaviour of fly toward man underwent a change quite as striking as in its behaviour toward pig. At first it was attempted to keep an exact record of the number of flies attacking the observer and the fly boys. From the 15th to the 20th inclusive only one fly bit and none engorged upon the observer. The fly boys were equally immune. During this period no one paid any attention to the fly nor was any effort required to ward it off.

On the 22nd December no difference was noted and no flies bit the observer.

On the 23rd "Flies were more active than I have seen them." Four flies bit the observer.

The 24th was a dull day. "Flies very inactive but bothersome. Four flies bit; others would have bitten if permitted to do so." The fly boys were equally annoyed, and considerable effort was required to keep flies at a distance.

On the 25th it was necessary to be constantly on guard against the flies. "The flies are hungry—very hungry. They attack man viciously, and it is impossible to estimate the number of times I have been bitten or would have been bitten but



for constant vigilance. All the fly boys were on the *qui vive*, and continually fighting off flies, in sharp contrast to complete indifference toward them on the 22nd and previously."

Undoubtedly more flies would have bitten man on the 25th than actually engorged upon the pigs that day, and their changed behaviour toward man was equally as notable as shown by the table (IX) toward pig.

This experiment of hunting the wild hosts of tsetse was accidentally repeated on the peninsula of Neozi on the island of Bugalla (Sesse) where camp was pitched in November 1914. There was a not heavy or noticeable infestation by tsetse, and the principle host of it was *situtunga*. But no sooner was the camp occupied than these animals evacuated the peninsula and were seen crossing the isthmus connecting it with the mainland one to two miles distant only a few hours after the men began work on the tent and huts. On the following day (Sunday) the behaviour of the flies was not notably changed, but on the third day they became so unbearably persistent in their attack that (in view of the possibility of human infection from their bites) the camp was abandoned.

Such conditions are likely to be produced in almost any fly-infested locality by the advent of a temporary population sufficiently large to produce a measurable effect upon host animals. They are particularly likely to be created when, as was formerly a custom of the natives, temporary fishing camps are located on small islets which are otherwise uninhabited. If a person infested by the human parasite is a member of such a fishing party conditions will be extremely favourable to the transmission of the organism to other members of the expedition.

## II (c). Correlation between High Percentage of Females naturally prevailing and Persistence of Attack upon Man.

The islands listed in Table X were visited in January and February 1914 in company with Dr. Carpenter. Large collections of fly were made and the average of male density and of female percentage recorded for the several observation points on each island is also given in the table. Dr. Carpenter and I were agreed, at the close of the tour, that the relative persistency of attack by fly upon man was fairly estimated as in the table.

The difference between behaviour of fly towards man on Kimmi and Damba, respectively, was truly extraordinary—equally as extraordinary as its changed behaviour on Lugazi islet following the banishment of its wild hosts. And these differences are strikingly correlated with variations in sex ratio, and not at all, or only as by accident, with variations in density of infestation (as measured by density of active males).

These observations have been many times confirmed, notably by the behaviour of flies on Bale fly beach (Table VIII), where the female percentage was 84.6, and where, despite constant vigilance, the observer was actually bitten about 15 times per hour. This is more times in one hour than he was bitten in more than six weeks spent in field work on the islands of Bulago, Kome, Damba, Tavu, Lula and others, from 1st November to 15th December 1913. A record was kept of the number of bites inflicted during this period and it totalled only 9. When the fly is no more

troublesome than this, the ordinary person makes little effort to ward off attack, and nearly every fly that cares to bite does so, but when the fly is as troublesome as at Bale, where "nearly every fly tried to bite" the ordinary person is continually on the alert to ward them off, and not nearly so many flies bite as would otherwise do so. The difference in behaviour of fly towards man on such islands as Tavu, Bulago, etc., and on the fly beach at Bale is even greater than the figures given above would indicate.

TABLE X.

*Correlation between Female Percentage and Behaviour of Glossina palpalis towards Man.*

Island.	Catch.	Density*	Females.	Behaviour of fly towards man.
Kimmi ..	1588	24.3	57.5 %	More troublesome than on any other island.
Wema ..	1413	30.5	39.1 %	At times or in places as bad as on Kimmi but not always so bad.
Yempaita ..	1382	42.6	37.9 %	About as bad as Wema would average.
Bulago ..	580	27.5	29.0 %	Not as bad as on preceding island, but bad enough.
Nsadzi ..	1080	18.4	24.6 %	Not as bad as Bulago, but worse than on Tavu at times.
Kizima ..	513	15.1	18.9 %	Not at all troublesome.
Tavu ..	674	46.6	17.1 %	Not as bad as on Bulago.
Damba ..	975	30.7	12.2 %	Less troublesome than on any other badly infested island.

\* Owing to the varying degree of activity of females the density of fly in any district or island must be based, for comparative purposes, on the catch of males alone.

## II (d). Experiment to test Variability in Behaviour of Fly towards Man on Kome or Damba Islands, as correlated with Variations in Abundance of Host Animals and Female Percentage.

In the autumn of 1915 a definite and detailed scheme was worked out for the reclamation of and re-establishment of the populations upon the Sesse Islands. One detail of this scheme was the placing of a colony [on the island of Kome (Fig. I), which in itself is one of the safest in the lake and could easily be made much safer, but which suffered severely from sleeping sickness owing to the nearness of the island of Damba, which, when populated, was probably the most insanitary island in the Sesse group; it must have been continuously much as Lugazi islet was after being occupied for three days by hunters of the wild hosts of tsetse. It would be entirely impractical to make Damba a safe place for a native population to live unless there were much more need for agricultural land than at present. But wild hosts were so numerous and female ratio so low that theoretically Damba, if unpopulated, and set aside as a bit of game reserve, would not be a source of danger to a population on Kome.

It was desired to test this theory by pitching camp on Kome, and spending some days hunting over and surveying both it and Damba, keeping accurate count of the number of times that flies actually bit—without engorging—during the days spent in

the experiment. This was done; camp was pitched squarely in the fly belt on Kome; three days were spent in exploration and survey of bush and old plantations along its shore; four hunting trips were made to Damba, and afterwards two days were spent in a camp located squarely in the fly belt on that island.

The results of the experiment are summarised in Table XI. Host animals were more than five times as numerous on Damba as on Kome, with the result that female percentage was very much lower. Density was not less than six times greater on Damba, but owing to the relative scarcity of wild hosts, fly was much more prone to bite on Kome, when one-sixth the number of flies inflicted nine times as many bites. This would indicate the fly to be nine times more likely to transmit disease on Kome than on Damba, although the density is only one-sixth as great.

TABLE XI.

*Comparison of the Behaviour of Glossina palpalis towards Man on Kome and Damba Islands.*

Basis of Comparison.	Kome.	Damba.
Number of hours spent in bush along shore at times when fly was active .. .. .	14	22
Number of hours spent in camp in fly belt, at times when fly was active .. .. .	10	8
Average density of fly in bush, about. .. .. .	5.0	30.0*
Average density of fly at camp, about .. .. .	5.0	15.0
Female percentage in bush .. .. .	38.1	10.2
Wild hosts of fly seen or flushed:—		
Varanus .. .. .	0	12
Situtunga .. .. .	7	50
Total .. .. .	7	62
Wild hosts seen or flushed per hour .. .. .	0.5	2.8
Number of times observer was bitten in bush. .. .. .	3	0
" " " camp .. .. .	4	1
Total .. .. .	7	1
Number of times bitten per hour in bush .. .. .	0.21	0.0
" " " camp .. .. .	0.40	0.12
Number of times bitten per hour spent on island .. .. .	0.28	0.03

\*The catches made during this trip indicate a somewhat heavier infestation than this, but it is known that they were too high; they were made at points where flies were concentrated, and allowance is made for lower average density.

The really striking comparison, however, is between the figures as given for Damba, and the note made during field work on the beach at Bale (see p. 362) to the effect that "nearly every fly tried to bite," and that 15 actually bit in less than one hour.

Density, as indicated by the male catch at Damba, is three or six times greater than at Bale, but at Damba 22 hours were spent in the bush without being bitten once, as compared with 15 bites in one hour at Bale, a proportion of less than 1 to more than  $15 \times 22 = 330$ .

Making allowances for error at every point, it is clear that density of infestation being equal, the fly is several hundred times more likely to feed upon man where wild hosts are very few and female percentage very high than when they are very many and female percentage low.

## II (e). Female Percentage as an Index to the Chances favouring Transmission of Human Trypanosomiasis.

Perhaps the most pertinent point in this connection is that the chances favouring transmission of the virus of sleeping sickness from man to man are vastly less proportionately when few flies feed on man than when many do so. The same fly must feed on or bite the human host twice in order to transmit disease from an infected to a healthy man. If only one fly in 500 or 1,000 actually bites man, the chances that that same fly will attack man a second time are absurdly small; if every second or third fly feeds upon or bites man the chances that the same fly will attack man a second time are stupendous in comparison.

The female percentage may thus be a very valuable index to the chances favouring transmission of human disease.

## III. THE LONG-SHORE MOVEMENTS OF *GLOSSINA PALPALIS*.

The explanation of the variable ratio between the sexes of *Glossina palpalis* provided by the early experiments proved inapplicable in many cases, and numerous vagaries in the sex ratio were observed which were for long inexplicable.

Eventually investigations into the long-shore movements of flies and the routes and courses followed by them in their food-hunting and otherwise stimulated flights, led back into the old problem of sex disparity and provided logical explanation for many variations in it which had been observed but which could not be correlated with abundance or scarcity of food. The same study also required consideration of "shelter" (arborescent vegetation sought or required by the flies for their protection) and of the relative attractiveness of different types of it.

These three, quite different topics—sex disparity, shelter, and movements of flies from place to place—had to be considered coincidentally in the field and cannot be entirely separated in reporting upon field work.

In the following sub-sections they are discussed as they were studied, inter-dependently.

### III (a). Experiment to test the Movements of Flies along the Lake Shore.

The larger catches of fly made on Bulago Island and recorded in Table I were from near the extremity of a long, narrow spit of sandy land designated in the notes as "Crocodile Point" (see Fig. I). The area of this spit was considerably less than of the islet of Lula, from which the flies were caught as recorded in Tables VI and VII. But though these catching experiments on Lula quickly brought about reduction in density of active flies, it was observed that no such effect was produced on the density of the fly at Crocodile Point. On the contrary, although more than 2,000 flies were caught there during the period 10th to 13th November, neither density nor female percentage underwent notable change (see Table XII).



TABLE XII.

*Catch of Fly at Crocodile Point, Bulago Island, showing Existence of Rapid Movement along Shore.*

Date.	Catch of Fly.		Density of Active Fly.*		
	Total.	Females.	Males.	Females.	Total.
5th November 1913. . . . .	564	27 %	14.2	5.8	20.0
10th     "     "     "     "     "	630	20 %	16.0	4.0	20.0
11th     "     "     "     "     "	944	28 %	12.5	5.0	17.5
12th     "     "     "     "     "	167	18 %	10.3	2.4	12.5†
13th     "     "     "     "     "	435	29 %	14.7	6.0	20.7
Totals and averages 1st experiment	2740	24.4 %	13.5	4.6	18.1
17th January 1914 . . . . .	912	40.3 %	24.4	17.1	42.5
20th     "     "     "     "     "	1102	48.2 %	27.5	26.4	53.9
21st     "     "     "     "     "	303	44.2 %	11.3	9.0	20.3†
22nd     "     "     "     "     "	606	48.0 %	26.5	28.9	55.4
Totals and averages 2nd experiment	2923	45.2 %	22.7	20.3	42.9

\* "Density" is the number of flies caught per fly-boy per hour.

† These days were somewhat dull and overcast, rendering flies inactive.

The fact that density of both sexes was perfectly maintained on the 13th November after four consecutive days of catching, when viewed in the light of the results of less extensive catchings on Tavu (Table V) and Lula (Tables VI and VII), can only be explained by the movements of fly along shore, and these movements must be quite free and rapid in order to account for it.

Notwithstanding the semi-isolated position of Crocodile Point, as many flies penetrated its area each day as were caught on it, leaving no other conclusion possible than that, if no flies had been caught, as many would have moved away from it. Otherwise stated, the fly population of this region was so far from permanently fixed there that hardly any individuals sojourned there for more than a single day.

The experiment of the 5th to 13th November 1913 was repeated on the 17th to 22nd January 1914 (Table XII) and completely confirmed it. The conclusions were subsequently confirmed in various other ways, and there is no doubt that the flies of this species move freely about from place to place, forming continuous streams of fly traffic along the shores of lakes, banks of streams, and, it was subsequently ascertained, along the borders of woodland, game trails or human pathways, etc.

### III (b). Movement of the Sexes along the Lake Shore.

Although it was impossible to reduce the local density of fly under such conditions as exist at Crocodile Point if an interval of several hours is permitted to elapse between periods of catching, it was easily possible to reduce the density of male flies—not of active females—by even a single hour's catching, provided no interval elapsed

before the experiment was repeated. In other words, if catching is continued over several consecutive hours, the density of male flies, but not of active females, will be reduced during the first hour, and will not rise again to normal until several hours have elapsed.

TABLE XIII.

*Catches of Fly for consecutive hours at points on Lake Shore, showing Reduction in Density of Males but not of Active Females, and demonstrating more rapid movement of Females.*

Locality.	Date.	Hour.	Catch of Fly.		Density of Active Fly.		
			Total.	Females.	Males.	Females.	Total.
Crocodile Point, Bulago Island	17th Jan. 1914 ..	1st	343	30·9 %	35·0	14·1	49·1
		2nd	319	41·4 %	26·7	18·5	45·2
		3rd	250	56·2 %	14·5	18·7	33·2
		1st	419	10·7 %	62·3	7·5	69·8
Landing Place, Tavu Island .	15th Jan. 1914 ..	2nd	250	10·4 %	37·4	4·3	41·7
		3rd	183	21·3 %	24·0	6·5	30·5
		4th	163	25·2 %	20·3	6·8	27·1
		5th	167	26·8 %	20·3	7·5	27·8

These experiments were many times repeated with results similar to those presented in Table XIII. It was found that the local density of male flies could be very quickly and easily reduced, whereas that of active females was not affected in this manner. It was conclusively proved by experiments cited on p. 365, and illustrated by Table XII, that reduction in density of males would be made good by incoming flies if some hours were allowed to elapse before a second catch was made, but that no period of waiting was required to make good any reduction in density of active females caused by catching.

The only conclusion that can be drawn is that the active females habitually move along shore much more rapidly than the males, or than many of the males. This is entirely in accord with the conclusions reached through experiments cited in Sect. I, that active females are hungry, and actively seeking food, and that degree of activity is correlated with abundance or scarcity of food. Their movements along shore are stimulated by hunger. The movements of the males are in part stimulated by hunger, but also in part (see Sect. IV) by sex instinct. The object of the females—and of such males as require it—is to seek food; the object of many of the males (forming a majority when females are inactive and the female percentage low) is merely to seek the females, and this is accomplished by loitering along the routes most freely followed by the food-hunting flies.

This conclusion found ample confirmation as the investigations progressed; as, for example, by the fact that when food is so scanty on an island (as on Kimmi Island in January 1914) that the female percentage is very high, it is impossible to reduce the local density of either males or females by catching experiments at

points where they are passing. Under such conditions nearly all flies are seeking food, and all are equally active, as clearly shown by a comparison between the figures presented in Table XIV and those presented in Table XIII.

TABLE XIV.

*Catch of Fly at a point on Shore of an Island where Food was deficient, and where nearly all Flies were seeking it, showing equal degree of Activity on the part of both Sexes.*

Locality.	Date.	Hour.	Catch of Fly.		Density of Fly.		
			Total.	Females.	Males.	Females.	Total.
Landing Place. Kimmi Island	{ 26th Jan. 1914 ..	1st	205	66·3 %	23·0	45·2	68·2
		2nd	249	66·3 %	28·0	55·0	83·0
		3rd	451	65·2 %	26·1	49·0	75·1
		4th	463	69·9 %	27·0	50·0	77·0
		5th	289	64·0 %	17·3	30·8	48·1*

\* Falling off in density during the 5th hour was due to approach of evening. The sexes remained proportionately as active as before, as shown by the female percentage for this period.

### III (c). Effect of Shelter, or of Type of Vegetation, upon Long-shore Movements of Fly and upon Percentage of Females in the Catch.

On 4th September 1914, a catch of fly was made under unusual circumstances on the island of Bukassa. The shore at this point was lined with a very dense fringe of reeds only two or three yards in width. Inside the fringe was open grass land, cropped very short by hippo, with scattered clumps of thick bush and trees of a sort affording attractive shelter to fly. At the observation point itself was a landing place of hippo with a trail forming a tunnel through the reeds. The prow of the canoe was thrust into this tunnel, with the stern projecting beyond the reeds into the open lake, and collections were made simultaneously by one boy stationed in the stern of the canoe, *outside* the thick fringe of reeds, and by two boys at and near the point where the hippo trail entered the opening, *inside* the fringe of reeds. These reeds, it should be noted, were at least 10 feet in height, or higher than tsetse is at all likely to rise from the ground.

The three boys worked for two hours with the following results:

					Inside Reeds.	Outside Reeds.
Catch per boy hour—						
Males	..	..	..	..	3·0	3·5
Females	..	..	..	..	·5	7·5
Female Percentage	..	..	..	..	14·3%	68·2%

The extraordinary feature of this catch was the low percentage of females (14·3) *inside* and the high percentage (68·2) *outside* the barrier formed by the reeds; the two points being separated by not more than 10 yards.

This same phenomenon was observed a second time under different conditions in a catch made on the 23rd September 1914 at a point on the island of Bussi, where two boys worked ankle-deep in water outside a thick mass of reedy vegetation that prohibited landing, and two other boys on a point of shelving rock, backed by an open space and bushy forest of a type much favoured by fly as shelter. The poorly sheltered, reed-fringed point on the shore was only about 100 yards distant from the attractively sheltered point.

The catch was as follows, for the four boys for half an hour:

Catch per boy hour—					Well sheltered Point.	Poorly sheltered Point.
Males	..	..	..	..	49.0	8.0
Females	..	..	..	..	3.0	13.0
Female percentage	..	..	..	..	5.8	60.8

As before, there is an extraordinary discrepancy in sex ratio between points separated, in this case, by only about 100 yards. And in both cases the high percentage of females is associated with a type of vegetation known to be especially repugnant as shelter and the low percentage with a type of vegetation known to be attractive.

A hypothetical explanation for this phenomenon, which has withstood all tests applied to it, is as follows:—

(a) The body or mass of active flies is continually in movement, and streams of flies are continually passing points along shore (see Sect. III (a)).

(b) These streams of moving flies are made up of (1) food-hunting flies of both sexes, which compose a variable proportion dependent upon abundance of food and which move rapidly; and (2) male flies which are not seeking food, but which frequent the routes followed by food-hunting flies, and which move much more slowly (see Sect. III (b)).

(c) The relatively idle and lingering males tend to prolong their sojourns at points where sheltering vegetation is of the most attractive type, and to pass quickly, or not at all, by points where the vegetation is of an unattractive type. It follows that (1) density of active males will be greatest where shelter is most attractive, and least where it is least attractive, and (2) that the percentage of females amongst caught flies will be greatest where shelter is least, and least where shelter is most attractive to the lingering males (because food-hunting flies must, for several reasons,\* consist principally of females).

When confirmation of this hypothesis was sought it was found on every hand, not only in new catching experiments and fly survey work, but in old records, made

\* These reasons include the following:—

1st. Because the females in any district or region appear to outnumber the males (see Sect. I (d)).

2nd. Because the females must nourish their young as well as themselves, and most probably require food somewhat more frequently, in nature, than males.

3rd. Because the males are normally active at all times during good weather, and are more apt than the females to encounter host animals without specifically seeking for them.



ong before. The records made on the island of Kimmi in January 1914 are an example. As presented in tabular form (Table XV) they are not particularly

TABLE XV.

*Catch of Fly on Island of Kimmi showing effect of variable character of Shelter on Density, Sex Ratio and Movements of Glossina palpalis.*

Date. (January 1914.)	Locality on Island. (Observation Point.)	Catch of Fly.		
		Male Density.	Female Ratio.	Total in Catch.
27th	.. South-easternmost point . . . . .	39.5	53.2	506
29th	.. North-eastern point . . . . .	15.7*	66.9	142
29th	.. North-western point . . . . .	43.3	52.2	272
24th	.. South-western point . . . . .	23.3*	62.9	384
27th	.. Southern shore . . . . .	42.7	53.0	276

\* Shelter was appreciably less attractive at these two points.

striking, but the correlation between shelter, local density of males, and female percentage is quite strikingly shown in figure 2. In this case the "shore line" in the graph represents the entire circumference of the island, a distance of between 2 and 3 miles, with five observation points located as stated. The difference in character of shelter was not particularly notable, but it was enough to produce the effect shown.

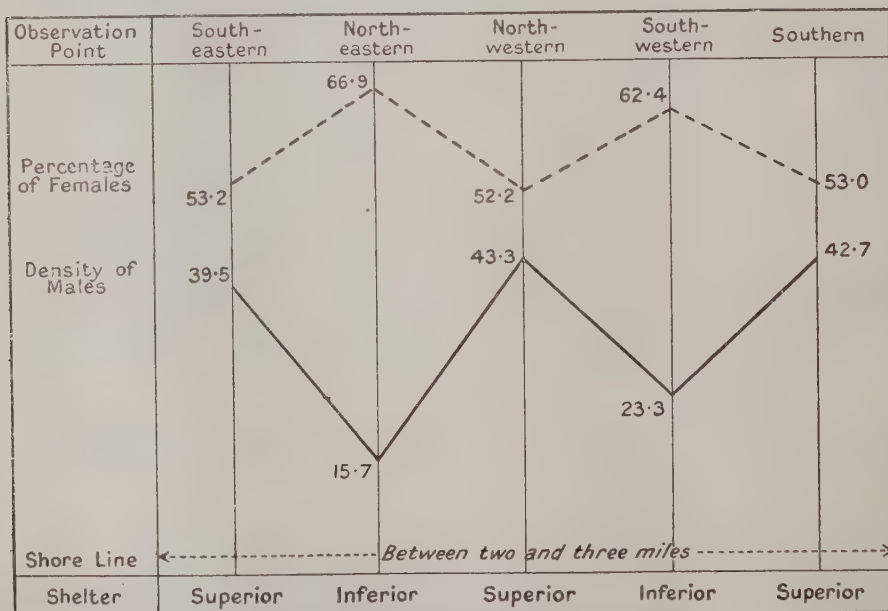


Fig. 2. Graphic representation of data given in Table XV.

Records made in the course of the fly survey of Bugaba Island as presented in fig. 3 afford a second excellent example of the correlation between character of sheltering vegetation, density of male flies and percentage of females in the catch. In this particular case there was a short reach of sandy shore at observation point 43 which served as a breeding ground for the flies, but which was poorly (too slightly) sheltered. At either end of this bit of sandy shore was forest, with marshy, reed-grown fore-shore of a distinctly unattractive type. Only where the forest growth came down to the more open sandy shore at points 42 and 44 was shelter really attractive

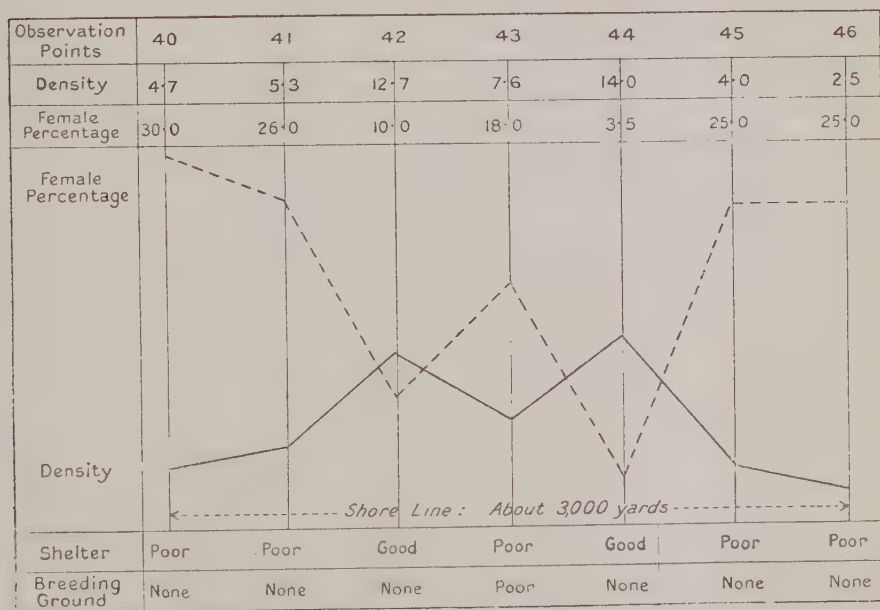


Fig. 3. Correlation between character of shelter, density of male flies and percentage of females.

Figure 3 shows an excerpt from the data secured during the "fly survey" of the island of Bugaba (vide Sect. VI. (g)) and illustrates conditions of infestation by fly along a reach of shore about  $1\frac{3}{4}$  miles in length. In all, more than 150 miles of mainland and island shore were systematically surveyed in this manner, and the data secured have served in scores of cases to confirm the conclusions herein stated concerning the correlation between character of shelter, density of males and female percentage.

A single other example may be given in Sect. III (d) which follows.

### III (d). Notes on Survey of Lutoboka Bay, Bugalla (Sesse) Island.

Figure 4 presents the results of a survey of some 5 miles of shore, principally included in the large circular bay that lies within the peninsula of Lutoboka on Bugalla (Sesse) Island. This survey was undertaken with the object of collecting data relative to the effect of environment upon range and density of *Glossina palpalis*.

It is impracticable to include in the graph data concerning environmental features responsible for the striking variations in male density and sex ratio shown by the curves. In general they are as follows :

Points 1 to 4 inclusive are typical of shore infested to slightly above the average extent for this general region. This reach of  $1\frac{1}{2}$  miles lies on the western shore of the bay, and is densely wooded, with bits of open shore alternating with reed-grown and jungly reaches. There were some sand and gravel deposits affording good breeding grounds.

Points 5 to 8 inclusive :—The forest continues, but there is no more open shore, nor any breeding places. Instead there is a fringe of floating sudd (papyrus and saw-grass) lying off-shore and no open space between it and the massive shelter of the forest behind. Catches were made from a canoe outside the sudd, which, with the exception of grass, is the most repulsive type of vegetation.

Only the hungry food-hunting flies (principally females) pass beyond the limits of the open shore at point 4. The relatively idle males turn back.

The minimum density of males and maximum percentage of females is recorded from point 6. At point 7 males are more numerous and female percentage has fallen, indicating that a new fly colony is being approached. The catch at point 8 confirms this and makes it certain that males are coming into the repulsively sheltered reach from the other direction.

At point 9 there is a break in the sudd, and an open grassy bit of fore-shore, scattered with bushes and backed by massive forest. Shelter is attractive, but as yet no breeding grounds occur. The excellent shelter makes for a sharp increase in male density and a corresponding decrease in female percentage.

At point 10, the forest, which has continued unbroken until now, ceases and open grassland comes down to near the water's edge. The foreshore is open, with scattered bushes, and deposits of beach sand afford excellent breeding grounds. For a short space between points 9 and 10 this series of open sandy belts is backed by the massive shelter of the forest. This combination affords complete protection to the flies, both as pupae and adults, and forms the centre of the colony, or centre of infestation for the shore on either side.

Beyond point 10 the open fore-shore, with sand deposits and the slight shelter of scattered bush, continues (as at point 10), but is no longer backed by massive shelter. The effect on male density and female percentage is precisely as caused by the fringe of sudd. The idle males turn back when massive shelter ends, and only the food-hunting flies, in part, continue.

At point 14 is a relatively thick mass of bush, which tempts a few males to linger, but not for long, and density does not rise again until, some distance further on, forest shelter is again encountered.

There is not the slightest doubt that in these observation points high percentage of females coupled with low density of males is due to insufficient or unattractive sheltering vegetation, leading to a partial segregation of the food-hunting flies of both sexes from the relatively idle and satiated males.

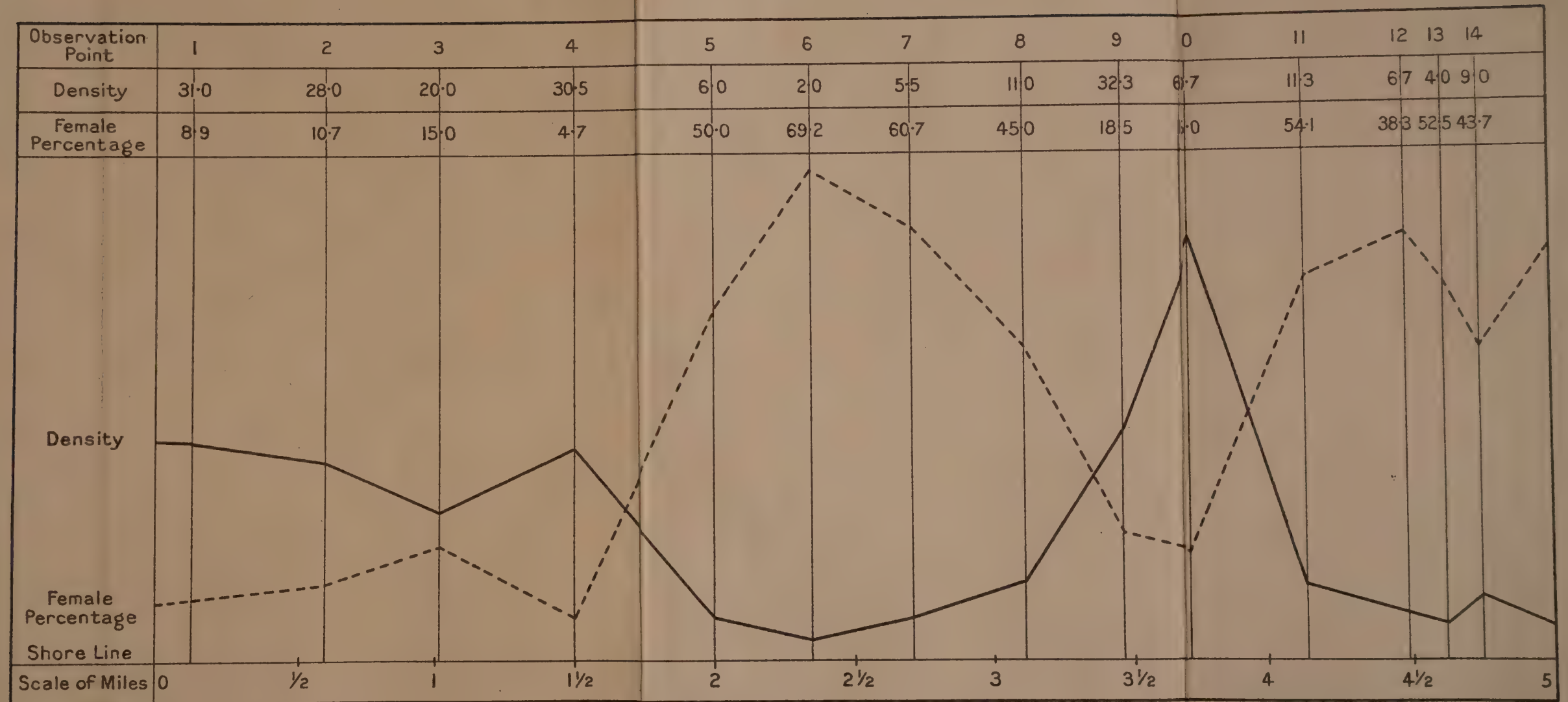


Fig. 4. Fly survey of a reach of shore in the district of Lutoboka, Island of Sesse (Bugalla), illustrating effect of environment on range, density and movements of *Glossina palpalis*.





### III (e). Maximum Percentage of Females brought about by Segregation through Movements.

The maximum percentage of females amongst active flies encountered at any point on island or mainland was in the district of Buddu between the old landing places known as Kalkosa (or Sekwe) and Bale. The figures of the catches made during a fly survey of this coast are presented in Table XVI. The distance from

TABLE XVI.

*Catch of Fly in the Mujuzi Colony.*

Date. (June 1915.)	Observa- tion Point.	Catch of Fly.			Density of Males	Percentage of Females.
		Males.	Females.	Total.		
24th .. .. .	40	26	39	65	26.0	60.0 %
24th .. .. .	41	12	90	102	4.0	88.3 %
22nd .. .. .	42	33	65	98	16.5	66.0 %
22nd .. .. .	43	23	68	91	11.5	76.2 %
22nd .. .. .	44	58	157	215	19.3	73.0 %
24th .. .. .	45	196	162	358	98.0	45.3 %
22nd .. .. .	46	106	103	209	53.0	49.2 %
26th .. .. .	47	41	73	114	20.5	64.0 %
26th .. .. .	48	45	120	165	19.3	72.7 %
26th .. .. .	49	20	84	104	10.0	80.8 %
26th .. .. .	50	10	80	90	5.0	88.8 %
Totals and averages ..		570	1041	1611	26.0	67.6 %
Average by points ..		..	..	..	26.6	69.5 %

point 40 to point 50 is about  $3\frac{1}{2}$  miles. Point 45 is at the mouth of Mujuzi Creek, which affords excellent harbour for crocodiles, as well as breeding places for the fly on its banks. It is the colony centre, and centre of infestation for a considerable reach of shore. Points 47 to 50 are in the Bale fly beach mentioned in Sect. II (a), Table VIII.

The average female percentage for this district is either 64.6 or 69.5 according to the method of computation, and compared with the maximum encountered on the islands (57.5 or 64.6 for the colony on Kimmi Island; vide pp. 363 and 370) is about 6.0 points higher. This is undoubtedly due to scarcity of food, which only occurred sufficiently or at all at the very mouth of Mujuzi Creek (point 45). The behaviour of flies bore this out completely. Nowhere else on island or mainland were they so troublesome; it was impossible to avoid being bitten, even with both hands employed wielding fly switches.

The extraordinarily high proportion of females at points 41, 49 and 50 break all records made elsewhere (for equally large catches), and are certainly explained by

the unattractive character of the environment\* at these points retarding the movement of the relatively idle and inactive males along shore. These males were concentrated along the short reach of shore including points 45 and 46; and elsewhere it was almost entirely the actively moving, food-hunting flies that were caught.

This particular colony of Mujuzi is in several other respects one of the most interesting and deserving of study of any encountered on either island or mainland. It is mentioned elsewhere, and a graph of it is presented facing p. 388. It was non-existent in 1906 but came into being subsequently as a result of environmental changes described on p. 458.

### III (f). The Full Significance of the Phenomenon of Sex Disparity in *Glossina palpalis* with Relation to Food Supply, Shelter and Movements of Fly.

The phenomenon of a variable ratio between the sexes of active flies of *Glossina palpalis* proved on investigation, as I have attempted to make clear, to be replete with interest and significance.

Taken over any considerable district or region it is a fair index to the abundance of preferred hosts, and thereby of the relative immunity of man to attack (see Sects. I and II).

Taken locally, point by point along a reach of shore, and coupled with the local density of active males at these same points, it becomes a subtle index to the attractiveness or repulsiveness of the local environment to fly. This fact having been conclusively proved, thereafter data in such local variations become of really great value in reaching conclusions concerning the relative attraction of various types of vegetation, etc., to the flies.

Finally, through study of this sex disparity and its causes, a very clear conception is obtained of the ordinary movements of the flies along the shores of the lake, banks of stream, borders of woodland, game trails, foot-paths, or other favourite courses. A great many little experiments and informal observations were made to ascertain the routes most freely followed by the active food-hunting flies—too many to mention in detail. The lake shore is the most favoured of them all, but, in general, they follow quite closely the line separating sunlight from shadow.

The flies are averse to penetrating shadow, unless sunlight is perceptible beyond, and even more-averse to crossing sunlit spaces unless shadow or massive shelter is perceptible beyond.

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\*It was not necessarily unattractive shelter that prevented the males from congregating at these particular points. They were distant from all sources of food, and however attractive shelter may have been (it was in fact very attractive at 49 and 50, but not at 41) no permanent concentration of males could occur.

The males tended to congregate at point 46, which was well sheltered; but not at point 44, just the other side of the creek, where shelter was not attractive. But by the time the relatively idle males had dispersed much beyond point 46, towards points 49 and 50, they began to require food, and there was no food unless they passed back to point 45, or passed far beyond point 50.

In other words, a reach of foodless shore, although supplied with both shelter and breeding ground, produces the same falling off in male density and elevation of female percentage as the shelterless shore described in the pages preceding this.

It was found by experiment, details of which need not be given, that flies will cross open channels up to at least 300 yards in width, but that they do not cross them very freely. It is certain that the width of the channel likely to be crossed is dependent on the character of the farther shore. Certainly they do not cross much wider channels than 300 to 500 yards at all freely, for from the beginning evidence of their doing so was carefully sought, and no shred of it secured.

It is the movements of fly along shore, or along the border line between sunlight and shadow, with which we are principally concerned, and these studies have shown how the flies tend to congregate in attractively sheltered localities, where, in consequence, density of males is high and percentage of females low, and how, pressed by hunger, both sexes, but more especially the females, tend to disperse from these centres of greater density and range along the lake shore or other favoured route in search of the sluggish amphibian animals on which they principally feed, thus accounting for the extraordinary preponderance of females amongst caught flies in repulsively sheltered localities.

#### IV. THE ASSEMBLING HABITS OF *GLOSSINA PALPALIS*.

The stimuli which keep in motion the streams of tsetse described in the preceding section are known to include, and believed in all ordinary circumstances to be limited, to the following:—

- (A) *Hunger*. Every second or third day the flies of both sexes undertake food-hunting flights. These are relatively rapid and easy to follow.
- (B) *Self-protection*. At the close of each period of activity the flies of both sexes are moved to seek massive shelter, where they remain in seclusion during periods of inactivity. They appear very unwilling to move far away from such shelter; hence flights in search of it are usually of short duration.
- (C) *Maternal Instinct*. At intervals of eight days, or longer, the females are stimulated to seek breeding grounds wherein to deposit their young. The great concentration of puparia in very attractive breeding places is proof that flights in search of them were of considerable duration. The location of deposits of puparia near the well-marked courses followed by food-hunting flies is proof that these are followed. But the flights themselves are very hard to follow.
- (D) *Masculine Instinct*. Every day, if the weather is good, the males appear all to leave shelter to undertake assembling flights. These are readily followed, and as described in the preceding section, are relatively slow. The insects tend to congregate or to loiter at points or along courses where the females are most likely to congregate or to pass. It is these special activities which are now to be considered.

Several points in connection with the assembling habits of *Glossina palpalis* in addition to those touched upon in the preceding sections are discussed in the subsections following. The topic is inter-dependent with several others, including, especially, host preferences of the flies.



#### IV (a). The "Following Swarm" of *Glossina palpalis*.

Many observations, but few detailed experiments were made upon the curious habit of *Glossina palpalis* of approaching and scrutinising strange objects. It was noted that there is ordinarily little discernible difference in this behaviour toward inanimate and animate objects other than their favoured hosts. When the percentage of females amongst active flies is low, man is almost immune to attack, but his person is none the less, and equally with any other similarly conspicuous object, strangely attractive both to the food-hunting flies of both sexes, and to the relatively inactive males. It is on this account that the males are so easily caught, whether or not they are seeking food.

Of all objects, apart from their favoured hosts, the most curiously attractive to flies is, perhaps, an open dark-coloured umbrella, and in the catching experiments and fly survey work the fly boys were each provided with one. When displayed at any point in or near the course followed by food-hunting flies, or the relatively inactive males, it becomes so conspicuous an object as to attract to it virtually all flies which perceive it. They crawl over it, especially its underside, inspecting it curiously until curiosity is satiated—or for, perhaps, one to five minutes—when they pass on. And this is equally true of both idle males and food-hunting individuals of both sexes. Despite the extraordinary attraction of the object there is no tendency on the part of any flies to linger more than the few minutes required for its inspection, so that a swarm will never collect. If the density of the stream of passing flies is 20 or 30 per hour, there will be from one to four or five flies resting on the attractive object at all times, but the same flies do not remain for long.

As above stated, the behaviour of the flies toward man is, ordinarily—i.e., when the man is alert, food is plentiful and the female percentage low—indistinguishable from their behaviour toward his coat thrown over a bush or his umbrella openly displayed. It is not necessary to think about the flies or to ward them off; occasionally one will bite, but the number doing so is so small that it is not worth thinking about. Man is attractive to flies, but does not hold them after their curiosity is satisfied. The same is true of goats, sheep, and many other animals.

But with certain animals under certain conditions the behaviour of the flies is conspicuously different. When a crocodile or *Varanus* is basking in half open sunlight, the flies attracted to them are apt not to pass on, after cursory examination, but to linger indefinitely. The result is the gradual accumulation of an accompanying or "following" swarm, which may grow to number several times more flies than a boy stationed at the same spot would be able to catch in an hour's time, and which may certainly represent (sometimes) the accumulation of the majority of flies passing the spot during several hours' time. Similar swarms may collect upon or near a foraging *Varanus*, as it wanders slowly through the woodland, or a grazing situtunga, and may then follow the animal out of woodland into open grassy spaces, where the flies would not go of themselves.

Mention of these conspicuous swarms of flies in connection with *Varanus*, crocodile, tortoise, hippopotamus and situtunga is made in Sect. VI (e). A few additional notes excerpted from my field books follow.

*On Varanus.* Kitobo Island, 3rd December 1913.

*Varanus* observed excavating burrow in sandy soil some little distance from shelter. On approaching it made off rapidly, and on reaching the spot I was assailed by a great number of tsetse, which swept back and forth and around me like angry bees, "buzzing" in their flight in a manner never before noted. After a few minutes they all dispersed, without any of them alighting upon me.

*On Varanus.* Nsadzi Island, 3rd February 1914.

A *Varanus* was suddenly flushed in grass land (grass about knee-high) not much less than a hundred yards from any shelter. It made off rapidly and a swarm of flies, numbering several dozen at least, rose and filled the air with their angry, bee-like "buzzing." As on Kitobo they swept back and forth and around about me, but none alighted or offered to attack, and in a minute or two all had dispersed.

*On Situtunga.* Bugalla Island, 23rd November 1914.

A large male situtunga was approached as it was feeding with its head concealed in a dense thicket. With glasses (Zeiss prismatic  $\times 12$ ) it was possible to make out that a peculiar dark colour of fore leg, lower shoulder and thorax, which were plainly seen through an opening in the bushes, was due to an unprecedented number of tsetse, which literally blackened its coat. It seemed entirely unmoved and phlegmatic under attack.

On being shot, the animal plunged directly through the thicket; ran a few yards at great speed and fell. On proceeding to the spot where it was feeding, I found a "following swarm" of fly of unprecedented size (probably not less than 200 flies) buzzing like a great swarm of angry bees. They surrounded me, but hardly any alighted on me or followed me to where the antelope lay.

*On Situtunga.* Damba Island, 13th September 1915.

A large male situtunga was shot in an opening in the forest in the dusk of evening. It ran into the thickly shaded forest and fell. On reaching it I was amazed to find a considerable swarm of flies, partly outside, but judging by the noise they made, more inside than outside the forest (it was so dark inside they could not be seen). Is it possible that a swarm will follow an animal into the night, and perhaps remain on its body all night?

*On Varanus.* Manene Island, 16th March 1915.

While passing through forest a movement in the vegetation (the ground was completely covered with broad-leaved herbage rather less than knee-high) indicated the approach of some small animal. It proved to be a *Varanus*, which came very slowly, evidently hunting insects and molluscs, to very near me. At no time could I see its body, but keeping pace with it and evidently following the movements of the herbage was a swarm of perhaps two dozen tsetse. The flies were not anxious to feed or to reach the body of the animal, but merely followed its movements, alighting on the herbage or hovering about. A movement on my part sent the animal scuttling rapidly away, whereupon the disappointed flies rose and swept back and forth, buzzing angrily as usual in such cases.

*On Situtunga.* Bugalla Island, December 1914.

(Original note lost.) On entering an open space in the jungle where formerly were plantations, a small herd of two female and two half-grown male situtunga was seen, with other animals feeding in the edge of the jungle out of sight. Those in sight did not immediately see me, who stood motionless watching them, nor upon seeing me did they betray alarm or more than mild curiosity. The whole herd moved in my direction and one female approached within three yards. Each animal was followed by a small swarm of tsetse—perhaps 15 or 20 flies—few of them on the animal itself, but principally on the vegetation close at hand, or hovering about. Not one of the flies was seen to feed, nor did the animals show annoyance at their presence. On becoming alarmed the antelopes made off without undue haste, the flies following.

The above may serve in some manner to make clear the difference between the behaviour of fly toward a favoured and complacent host, and such another as man, who is neither favoured nor complacent. Anyone passing through infested territory and aware of two or three, or perhaps half a dozen, tsetse constantly hovering about him is certain to receive the impression that this number of flies is persistently following him. In the case of *Glossina morsitans* the impression would, probably, be correct, for man will collect a following swarm of this species; but with *Glossina palpalis* it is incorrect. The same individual flies will not follow a man for more than a few minutes unless they are very hungry, but will quickly drop behind and be replaced, perhaps by others. This is easily proved by catching them just as they appear; one will quickly catch many times more than appear to be following at any one time.

The explanation of the "following swarm" with *Glossina palpalis* is, without doubt, identical with that put forward by Lloyd for the "following swarm" of *Glossina morsitans*. It is the assembling habit of the males; first, to linger along the routes followed by the food-hunting females; secondly, to examine any strange object coming in range of vision; and finally, on encountering a complacent host of a favoured species, to remain by it; for in these ways they are most likely to come into contact with the seclusive females.

Nothing else in the habits of the fly affords more convincing evidence of their unwillingness to feed upon man, unless they are forced by hunger. Far from attracting a following swarm, man cannot even hold one that has already been attracted to some other host; if by his approach he startles the favoured host into flight, there is not the slightest tendency on the part of the following flies to turn their attention to him, but invariably, as in the cases noted above, the swarm has dispersed without the flies paying as much attention to the intruder as is usual when other hosts are about.

#### IV (b). Conditions under which a Following Swarm will Collect.

More than 25 separate experiments were made with various wild and domestic animals tethered at points where they were exposed to columns of food-hunting flies, mainly to ascertain the host preferences and feeding habits of the insect, and finally in a specific effort to induce a "following swarm" to collect under observation. In the very first experiment in the series such a swarm did collect upon a tethered *Varanus*, but all other experiments failed in this respect.



Under entirely natural conditions swarms had been seen on *Varanus*, situtunga, crocodile, hippopotamus, pig (of domestic stock, but run wild) and tortoise, and most freely of all on *Varanus*. The fact that repeated attempts to induce one to form on *Varanus* which were held in constraint all failed, excepting only the first (see Sect. VI (c), experiment 4), convinced one that something more than the mere presence of a host animal of a favoured species is necessary, and failure is believed to be due to the impatience of these animals under restraint. In other words, a host must be complacent under attack as well as of a favoured species or it will not be favoured by tsetse to the extent of attracting a "following swarm."

The final experiments with *Varanus*, sheep and oxen are described in Sect. VI (c), experiment 3. They led to the conclusion that a host to be "favoured," must always be complacent, and suggested that perhaps almost any of the larger animals, including man, might be favoured, even to the extent of collecting a "following swarm," if it were in them to suffer the attacks of *Glossina* without sign of protest.

#### V. THE EFFECT OF OPEN WATER AND HUMID CONDITIONS UPON THE RANGE OF GLOSSINA PALPALIS.

No factor in the bionomics of *Glossina palpalis* is more obviously correlated with the range or distribution of this species than open water. It is a riparian species, and its occurrence far from shores of lakes or banks of streams is a subject for remark whenever observed.

Exceptional dispersion inland, however, is not at all rare, and many cases of it were encountered and studied. In all cases the explanation was the same, and involved, as virtually every topic in *Glossina* bionomics seems bound to involve, the subject of hosts and host preferences. The two topics are inseparable in field work and cannot well be separated in discussing and recounting field work.

These studies were more convincing to the observer than it is feared they may prove to the reader, that the correlation in question is purely coincidental; that water or humid conditions are not of direct benefit to the insect, nor required by it; but that a proper combination of food, shelter and breeding places which is requisite to its existence occurs so infrequently away from the shores of lakes or banks of larger streams that it is perforce riparian in habit.

##### V (a). Range of Fly inland from Lake Shore.

Ordinarily the range of fly inland from the lake shore is extremely limited; at 50 yards there will usually be a sharp reduction in density: beyond 100 to 200 yards flies will appear only as stragglers; and at 300 to 500 yards they will disappear, or, at least, density will drop below any figure that can be conveniently measured. If range inland is more extensive than this, some special cause for it must exist.

Attempts to measure the ordinary inland range of fly were limited to a single experiment on the island of Kitobo in December 1913, which resulted as follows—the catch being made at the base of a slope that rose rather steeply to a plateau with abandoned plantations.



Catch at base of slope, 5 $\frac{1}{4}$ "boy hours," showed density (both sexes) of .. .. .	15.50
Catch half-way up slope, 16 "boy hours," showed density of .. .. .	1.05
Catch at crest of slope, 28 "boy hours" showed density of .. .. .	.26
(This point was well under 300 yards from the water's edge.)	
Catch in old plantations beyond the crest of slope, 14 "boy hours," was .. .. .	Nil.

This is probably a sharper decline in density than usual, but not excessively so

#### V (b). Effect of Marshes and Rivulets on Range of the Fly.

The effect of lakes or streams on the range of *Glossina palpalis* is so conspicuous that whenever any unusual extension of its range inland from lake shore or bank of large stream has been observed it has almost always been accounted for as being due to presence of small streams, marshes or humid conditions of life generally. Therefore if any island were to show inland range of fly too much in excess of that noted as "normal" in the preceding sub-section, the question of interior conditions with respect to water and elevation (dryness) is the first to be considered.

A survey of the islands was begun in January 1914 to ascertain and measure variations in degree of local infestations, as they might be correlated with differences in local environment. Mostly small islands, of less than 1,000 yards short diameter, were visited; but by the 1st September out of a total of some 40, 8 of larger size had been included in the survey, and conditions with respect to infestation by fly, humidity and topography of the interior of each of these islands were found to be as stated in the accompanying table (XVII).

TABLE XVII.

*Fly Survey of Islands in Victoria Nyanza showing Lack of Correlation between Humidity of Interior and Infestation by Glossina palpalis.*

Island.	Conditions in Interior.		Infestation by <i>Glossina</i> .	
	Topography.	Humidity.	Shore Line.	Interior.
Wema .. ..	Hilly .. ..	Dry† .. ..	Dense .. ..	None.
Damba .. ..	Flat .. ..	Streams and marshes ..	Dense .. ..	Medium.
Kome .. ..	Hilly .. ..	Streams .. ..	Light .. ..	None.
Kitobo .. ..	Plateau .. ..	Dry* .. ..	Medium .. ..	None.
Bukassa .. ..	Hilly .. ..	Dry* .. ..	Light .. ..	Light
Bugaba .. ..	Hilly .. ..	Streams .. ..	Light .. ..	None.
Bubembe .. ..	Hilly .. ..	Dry† .. ..	Light .. ..	None.
Bugovu .. ..	Hilly .. ..	Dry† .. ..	Light .. ..	None.

\* Careful survey showed no streams near points of interior infestation.

† Streams may exist on parts of islands that were not explored.

It will be seen that of the eight islands listed, two differed from the rest in being infested in the interior. One of these, Damba, is flat, with streams and marshes in its interior, and with a dense infestation of fly along shore. Two others—Bugaba and Konic—also had streams flowing down from the hills, but they were hilly and the infestation along shore was light. Either elevation or lightness of infestation along shore might be a possible explanation for absence of fly inland, and its absence is merely negative evidence that it does not always occur in humid localities near lake shore colonies.

But in the case of Bukassa Island we have a dry, hilly interior, with only a light infestation along shore, and for all this a general infestation of the interior. This is not negative, but is absolutely positive and very strong evidence that, whatever it may be which restricts the range of this tsetse to a narrow belt along the shore of the islands generally, it is *not* the presence of water or soil humidity, for the interior of Bukassa is, perhaps, the driest and hilliest of any of those listed except Wema. And whereas it is perfectly possible that the presence of open water might account for infestation by tsetse of a belt several miles in width along the borders of it, it is impossible to consider water alone as the determining factor when, on some islands, the inland range of fly is virtually limited to 500 yards or less, whereas on others it is extended to 1,500 yards and more, and with no surface water in sight.

Slight though this evidence is, it is of such a positive character that it is practically conclusive. Some other factor than open water must be held accountable for limitation to inland range of *Glossina palpalis* from shores of lakes or banks of streams.

#### V (c). Effect of Food Supply on Range of the Fly.

A comparison between the two islands, Bukassa and Damba, in search of points of similarity, which should at the same time be points of difference between these and the other islands named in Table XVII, led to the conclusion that the most probable explanation for their infestation interiorly by tsetse was the presence of unusually large numbers of game animals: of situtunga on Damba, and of domestic pigs run wild on Bukassa. This conclusion was reached reluctantly, because at that time (September 1918) it was believed that the only favoured hosts of this species of tsetse were reptilian.

The course of the fly survey of the islands was thereupon set to include careful study of conditions on all such as were known or suspected to be more than usually well stocked with game. These included specifically the group of semi detached islands of Bukone, Serina and Lulamba, and the island of Buvu, upon which pigs were known to occur, and the (relatively) very large island of Sesse (Bugalla-Buninga), which had been reported to be overrun with situtunga.

Examination of the pig islands disclosed the fact that though great numbers of the animals had been present (enough to cover them with networks of trails and to uproot the soil nearly everywhere in the woodland) some great catastrophe had reduced their numbers to a few stragglers. More skeletons were found than traces of living animals. But one result of the visit was to discover a "following swarm" of fly about a pig that was shot, and to prove conclusively enough that this animal may be a favoured host. None of the islands was found to be infested by fly except very narrowly along the lake shore.

On Sesse the outcome was much more decisive. Situtunga were found everywhere in numbers which are extraordinary for an antelope accounted "rare" and a denizen only of marshes. They were even more numerous in the overgrown plantations and village sites on the plateaus, and elsewhere on the higher levels, than in the woodland and marshes along shore. The island is nearly forty miles in length, and eventually was explored from end to end. Practically every bit of woodland or jungle upon it was found to be infested by *Glossina*, including points in the interior of the western peninsula known as Buninga that are at least  $2\frac{1}{2}$  miles from the lake. The only exceptions were certain areas of woodland in the central portion of the eastern half of the island (Bugalla) which, though hardly a thousand yards from the lake, were completely surrounded by open grass land. Elsewhere a great diversity of inland environment was found: high hills and low; marshes and rocky summits; original forest and the frequently impenetrable jungles which have sprung up in the abandoned plantations; but everywhere that shelter at all attractive to the flies was found, there would be both situtunga and fly.

Except at the very beginning formal records of "catches" in the interior were not kept, because the work of exploration was done almost entirely on dull days or at hours (after 3 p.m.) when the flies are not as active as earlier. The records made at the beginning are presented in Table XVIII, in comparison with those from Bukassa, where inland extension of range is due to great numbers of pigs.

TABLE XVIII.

*Catches of Fly on Islands of Bukassa and Sesse (Bugalla) showing Inland Extension of Range due to Presence of Game, made in September 1914.*

Collection Points.	Bukassa Island.		Bugalla Island.	
	Male density.	Female ratio.	Male density.	Female ratio.
Lake shore .. .. .	9.8	10.1 %	24.2	22.5 %
Sandy plain, 400 yards inland .. .. .	—	—	25.0	16.6 %
Hills, 1,000 to 2,000 yards inland .. .. .	2.2	10.0 %	10.0	7.5 %
" 2,000 " 3,000 " " .. .. .	—	—	4.7	9.4 %
" 3,000 " 4,000 " " .. .. .	—	—	1.3	} None Caught.
" 4,000 or more " " .. .. .	—	—	.4	

Of significance is the low percentage of females in the interior points; indicating attractive shelter or ample food supply or both.

The only other host animal occurring on the islands, that is found at all commonly more than a few yards from the water front during hours when flies are active, is the monitor lizard (*Varanus*)\*. On certain islands—notably Manene and Dziru,

\* Except on the sudd-surrounded islands of Baujako and Binga, where bush-buck, bush-pig and buffalo occur, and which are faunistically a part of the mainland.

both of very small size—it is extremely common, and on the island of Mbugwe it is far more numerous inland than is usual. On these islands, also, unusual extension of inland range of fly was noted, as described more in detail in Sect. V (d) following.

At the end of the island survey the conclusion was definitely reached that the range of fly inland up to a distance of approximately  $2\frac{1}{2}$  miles is controlled in the islands by the abundance of food. A summary of observations on this point in tsetse bionomics is presented in Table XIX.

TABLE XIX.

*Fly Survey of Islands in Victoria Nyanza showing Correlation between Abundance of Host Animals and Infestation by Glossina palpalis in the Interior.*

Island.	Infestation by Fly.			Host Animals in Interior.		
	Shore.	Interior		Pig.	Situtunga.	Varanus.
Wema .. ..	Heavy	None	None	None	Few.	
Kome .. ..	Light	"	"	Very few	Very few.	
Bugabu .. ..	Light	"	"	"	"	Few.
Bubembe .. ..	Light	"	"	Few	"	"
Bugovu .. ..	Light	"	"	Very few	"	"
Buvumira .. ..	Light	"	"	"	"	"
Fumbe .. ..	Light	"	"	Few	"	"
Bunyama .. ..	Light	"	"	Very few	Very few.	"
Lulamba .. ..	Light	"	Very few	None	Few.	
Buvu. .. ..	Medium	"	"	"	"	"
Bukone .. ..	Light	"	"	"	"	"
Serinya .. ..	Medium	"	"	"	"	"
Kitobo .. ..	Medium	"	None	"	"	"
Bukana .. ..	Light	Light	Many	"	"	"
Damba .. ..	Heavy	Medium	None	Many	"	"
Zinga .. ..	Very heavy	Light	"	"	"	"
Sesse (Bugalla):—						
Western Portion ..	Heavy	Light	"	Very many	"	"
Northern " ..	Heavy	Medium	"	"	"	"
North Central Portion ..	Medium	Light	"	"	"	"
South " ..	Medium	Light	"	"	"	"
Southern Portion ..	Heavy	Medium	"	"	"	"
Mbugwe .. ..	Medium	Medium	"	Very few	Many.	
Manene* .. ..	Medium	Medium	"	"	"	Very many.
Dziru* .. ..	Light	Light	"	None	Many.	

\* Manene and Dziru are small islands less than 1,000 yards in short diameter, but are remarkable in that infestation of the interior is equally as heavy in the case of Dziru and heavier in the case of Manene than along the shore.

#### V (d). Inland Range of Fly as affected by Varanus on the Islands.

##### *Manene Island.*

Manene Island is, perhaps, 1,000 yards in length by 500 in breadth. Its northern half is elevated and rocky, its southern half low and fertile. Mostly it is covered with thick bush or forest, except for the rockiest places, and also excepting the site of old plantations in the very middle of the southern half, which are kept open and closely grazed by hippopotamus. These spaces are entirely surrounded by thick bush or forest.



*Varanus* was more common than on any island of similar size visited. Perhaps as many as six per hour were flushed during the survey of it. They were everywhere, but were especially common in the clear space above-mentioned, where many had their burrows.

There were several bits of sand or gravel beach which offered good breeding grounds and excellent shelter for fly, but the shelter in these was less attractive than that in the close-cropped clearings, surrounded by forest, bush or jungle and with bits of massed vegetation breaking the openings everywhere

The catch of fly was as follows :

					Male Density.		Female Percentage.
Shore points ..	..	..	..	..	12.3	..	21.7
Inland clearing ..	..	..	..	..	21.0	..	1.8

This is quite an exceptional case of concentration of fly away from the water (150 to 200 yards), due to more attractive shelter and constant abundance of food. No breeding places could be found except on the water front.

#### *Dziru Island.*

Conditions generally similar to those on Manene, except that shelter in the interior was not so attractive and concentration of fly less notable.

#### *Mbugwe Island.*

Mbugwe Island is about two miles in length by one in greatest breadth. It is densely forested, and appears never to have been cleared for cultivation except at a few points, now overgrown with jungle. The one open space discovered on the island is on the crest of a steep hill that occupies the centre of the broadest portion. The very summit of the hill is flat rock, partly covered with thin soil, rank grass and scattered bush. The shore is generally rocky with here and there bits of beach.

*Varanus* is common. Ordinarily this reptile occupies burrows in rocky places or excavated in light soil in grassy openings, near which are located its habitual basking spots. On Mbugwe there are no such openings as are frequented by it—at least none were seen—except on the crest of the hill above-mentioned, the slopes of which to the very edge of the water were covered with dense, old forest. Hence, although this opening was fully 800 to 1,200 yards from the water, it was much frequented by the animals, which had fairly covered the soil in places with their excreta (containing shells of crabs and molluscs from the lake).

The catches of fly made on this island (4th and 5th March 1915) were as follows :—

					Catch.		Male Density.		Female Percentage.
Points on shore ..	..	..	..	..	187	..	16.6	..	33.5
Crest of hill ..	..	..	..	..	83	..	13.7	..	50.6

Breeding grounds were sought for and found in and near the basking spots of *Varanus*, in dry vegetable debris that partly covered the rocks. Six boys, searching for one hour found :

						Total.		Per Boy Hour.
Empty shells ..	..	..	..	..	..	55	..	9.2
Healthy puparia ..	..	..	..	..	..	21	..	3.5

The shells had all hatched, and none had been eaten or destroyed by small predators.

This particular colony is the one and only inland infestation discovered at any point which appeared to be quite independent of colonies on shore, and this is the only occasion on which breeding grounds adequate to sustain an independent colony have been found except in old or recent deposits of beach sand or gravel.

The conditions are unique in many respects. The very dense forest which clothed the slopes of the hill was a strong deterrent to dispersions of fly. The local environment was far from being attractive, and it is exceedingly doubtful if the flies would have remained in it if the thick forest had not been so relatively less attractive. But they were walled in as on an island, or as in a great breeding cage—it chanced that there was a regular supply of food—it chanced that there was protection for the pupae—and in consequence the flies remained and bred.

There is no reason why such colonies should not be found at any distance from the water front, except that such conditions are exceedingly rare in this region.

#### V (e). Dispersion of Fly inland from the Mainland Shore.

At numerous points on the mainland it was ascertained that inland dispersion of fly was no more extensive than is usual on the islands. The two notable exceptions follow.

##### *Dumo Point, Buddu, June 1915.*

Dumo Point is a peninsula with a hill and old plantations, separated from the mainland by an open plain. It is in large part dense jungle. Near the very centre, about 500 yards from the lake shore on two or three sides was a semi-open space, kept grazed by hippo, in which grew great quantities of guava. Bush-buck was rather common. A herd of bush-pig had a retreat in the jungle, and clearly marked trails showed where it made regular rounds of the guava thickets for the fallen fruit. In the immediate vicinity of this thicket, but not elsewhere except in the usual narrow belt along shore, *Glossina* was common. The catches stand as follows:

			Male Density.	Female Percentage.
Points along shore of peninsula	..	..	11.6	.. 61.2
At guava thicket, 500 yards inland	..	..	8.8	.. 21.4

The shelter at this point was quite attractive, but no more so than at many other points; the inland dispersion of fly was distinctly unusual and the presence of both bush-buck and bush-pig, the latter particularly, led to the conclusion that the presence of fly was thus explained.

##### *Bujaju Peninsula, July-August 1915.*

Bujaju Peninsula is an extensive tract of land, almost an island, but with the deep bays behind it choked permanently with sudd. Its shore is very marshy, and principally fringed with papyrus; but inside the papyrus are open spaces, with occasional bits of sandy soil, or traces of old beach line, and these are sparsely infested by tsetse. The interior is much of it "impenetrable" jungle, cut with great numbers of hippo trails, and with clearings, closely cropped by hippo, where once were villages

and plantations. Not far from the northern extremity are natural clearings, with very short grass and flat outcropping ledges of rock, and where the soil is sufficient, exceedingly dense clumps and thickets of bushes and vines.

Everywhere on the peninsula the inland range of fly appeared to be normal, except in these natural clearings, which extended a mile or more and were distant 800 to 1,200 yards from the water. Catches were attempted in the clearings kept open by hippo, but without result, or only straggling flies were caught; but in the natural clearings the greatest density of fly was found of any point on the peninsula. The records are

	Male Density.	Female Percentage.
Points along shore of peninsula opposite clearings	5.9	.. 42.3
Point nearest clearing on foreshore .. ..	9.0	.. 51.1
In clear space kept open by hippo 100 yards inland opposite natural clearings .. ..	9.5	.. 15.5
In hippo trail leading to clearing 400 yards inland	10.0	.. 12.0
In clearing, 800 to 1,000 yards inland .. ..	11.0	.. 17.5
In open space 300 to 1,500 yards beyond clearing	nil	.. —

Breeding grounds were sought but not found; but this is no proof that they may not have existed. The shelter was of a most attractive type, but no more so than in other clearings, kept open by hippo, where the soil was much deeper and the vegetation more luxuriant. The only explanation for the presence of fly in such unusual numbers—for, in fact, the major concentration of fly on the peninsula so far as the survey of it extended—was the excellent shelter (probably coupled with breeding grounds) and rather unusual numbers of bush-buck, which appeared to be virtually the only source of food. It was less the numbers, however, than the easy accessibility of these animals which was conceived to be mainly responsible. They found refuge in the dense thickets and clumps of bush, which were so small in extent that the flies could find them at all times without penetrating far into the shadow.

#### *Kitebo Peninsula, August 1915.*

Kitebo Peninsula in the district of Mawakota, is bounded by permanent sudd fields, except for a reach of about 3 miles along its south-eastern and southern shore. Here it is narrowly-fringed with sudd of more recent growth and less permanently lodged, which in 1915 was broken at three points. Each break was the centre of a colony, or centre of infestation, for the space between the breaks and on either side of the semi-open reach.

To the northward, behind the permanent sudd fields that fill the channel between the peninsula and the island of Bujako, infestation falls away abruptly. To the westward, behind the permanent sudd fields that bind the western shore and south-western extremity of the peninsula a curious situation was discovered.

The south-western extremity of the peninsula is a marshy plain with belts and patches of drier land. The wetter parts of it are overgrown with a terrible tangle of tall grass, shrubbery and briery vines that defies penetration. The drier parts are in places open game pasture, and in part covered with patches of dense jungle.

The whole area forms a triangle, with its base against the higher ground (densely forested) and its apex lost in the tangled mass of vegetation that stretches outwards into the sudd.

Crossing this area, some distance from and very roughly parallel to the forested base of it, is a sandy ridge, densely overgrown with shrubbery and jungle. The tangled marsh is beyond this ridge, and inside it are the game pastures, very closely cropped by hippo and bush-buck. (Hippo crop almost as closely as sheep, using their horny-edged lips.) The ridge is an ancient beach line and affords fair breeding grounds and adequate shelter, which is supplemented by the patches of jungle scattered over the game pasture.

In addition to bush-buck, which were unusually common, were plenty of more or less recent tracks of water-buck, bush-pig and buffalo, which came out from the forest, and from other game pastures 2,000 to 3,000 yards through the forest.

The infestation along the ridge was interesting :—

	Catch.	Male Density.	Female Ratio.
At break in sudd, and hippo landing	195	44·5	54·3%
200 yards from open water, on ridge	114	29·0	49·1%
700       "       "       "	64	20·0	37·5%
1,100     "       "       "	55	20·0	27·2%
1,500     "       "       "	17	6·5	23·5%

There could be little doubt, in this case, that the bush-buck were mainly responsible for inland dispersion, for they greatly outnumbered the other game animals; of *Varanus* there was none, of crocodile but few, and the hippo herd slept far away from its nightly pasture.

There was also infestation at open points in the forest at distances believed to be 2,500 yards from the lake, but it was slight and not accurately measured. At the game pastures from 3,000 to 5,000 yards away from the open water—not far from the western sudd field—no fly could be found; water-buck was the principal species grazing in them.

#### V (f). Dispersion of Fly inland from Lake Shore along small Rivers.

At various points on the western shore of the Lake, in the district of Buddu, larger streams or creeks than exist on the islands flow into it. One of these, Mujuzi, enters the lake about two miles north of the old canoe landing at Kalkosa, and three miles south of that at Bale. South of the creek all the way to Kalkosa the shore is marshy, with an old beach line overgrown with dense vegetation. At the mouth of the creek an old sand beach begins, at a level of some two to three feet above the present beach line and continues nearly to Bale. The foreshore also is sandy, but except for a reach of 600 to 800 yards just north of the creek, it is overgrown with dense vegetation of an impenetrable character to the water's edge.

At the mouth of the creek the breeding grounds and shelter are of the best, and food is provided by a large number of crocodiles which find harbour there, and which also rest in the sand. To the north there is some breeding ground, but



shelter is repulsive and no indication of any sort of food was seen. To the south there are situtunga and perhaps other host animals, but shelter is repulsive and no breeding grounds were seen. Conditions of life at the very mouth of the creek, over a radius of hardly more than 50 yards, are highly favourable for tsetse, but favourable conditions are extremely localised, making for a sharply defined colony that fuses with a small colony at Kalkosa landing (point 40 in Fig. 5), to the southward, but tapers away to a minimum of 5 at Bale (about 1,200 yards beyond point 53), where a colony yet further north fuses narrowly with it.

Mujizi Creek is almost a river, being at points some 10 yards in width and of considerable depth. Its shores are thickly wooded, and cannot well be followed because of the tangled vegetation. There are occasional pools with low sand bars, as at points 45C and 45D. The stream was quite open as far as point 45E, where it was choked with floating vegetation which extended for a considerable distance. At points beyond 45F it was open again, and at one point ran through a tract of woodland which seemed the headquarters of a herd of buffalo, but beyond point 45F, which was approximately 2 miles from its mouth, no fly was seen. At no point from the mouth inland was shelter especially attractive: no breeding grounds were seen, and host animals were certainly not abundant.

If allowance is made for the general attractiveness of the shelter from point 45 to beyond point 46 along the lake shore, the falling off in density of fly appears to be approximately the same on the lake shore northward to Bale, and along the creek inland. It is more pronounced along the creek, but not very much more. The conditions of life are unfavourable to tsetse in all three directions from the colony centre, and infestations of the creek banks and lake shore alike for a distance of from two to three miles is plainly due to the existence of exceptionally favourable conditions in the extremely limited space around the mouth of the creek.

Extension of range inland along other creeks wide enough to create something of an alley-way through the bush or forest for the moving flies to follow has been found to be much as in this instance.\* The flies follow the waterways much as they follow the lake shore. But as yet no colony centre, or semblance of such comparable to the hill colony on Mbugwe Island (Sect. V (d)) or the inland colony in Bujaju (Sect. V (e)) has been discovered on the banks of any stream.

Every bit of evidence that has been gathered supports this final conclusion concerning the range of fly inland from the lake shore: it is primarily controlled by the distribution of host animals, and there is nothing to indicate that this tsetse requires open water or humid conditions, or that water is even attractive to it. Its favoured hosts are amphibious in habit, the most attractive types of shelter occur more commonly near the shore than inland; and it rarely finds good breeding places elsewhere.

It may be added that every instance in which fly was encountered other than as mere stragglers at a distance greater than 500 yards from the lake shore has been covered in this section.

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\* If the stream is so small that no break is caused in the continuity of the forest, fly has not been observed to follow it.

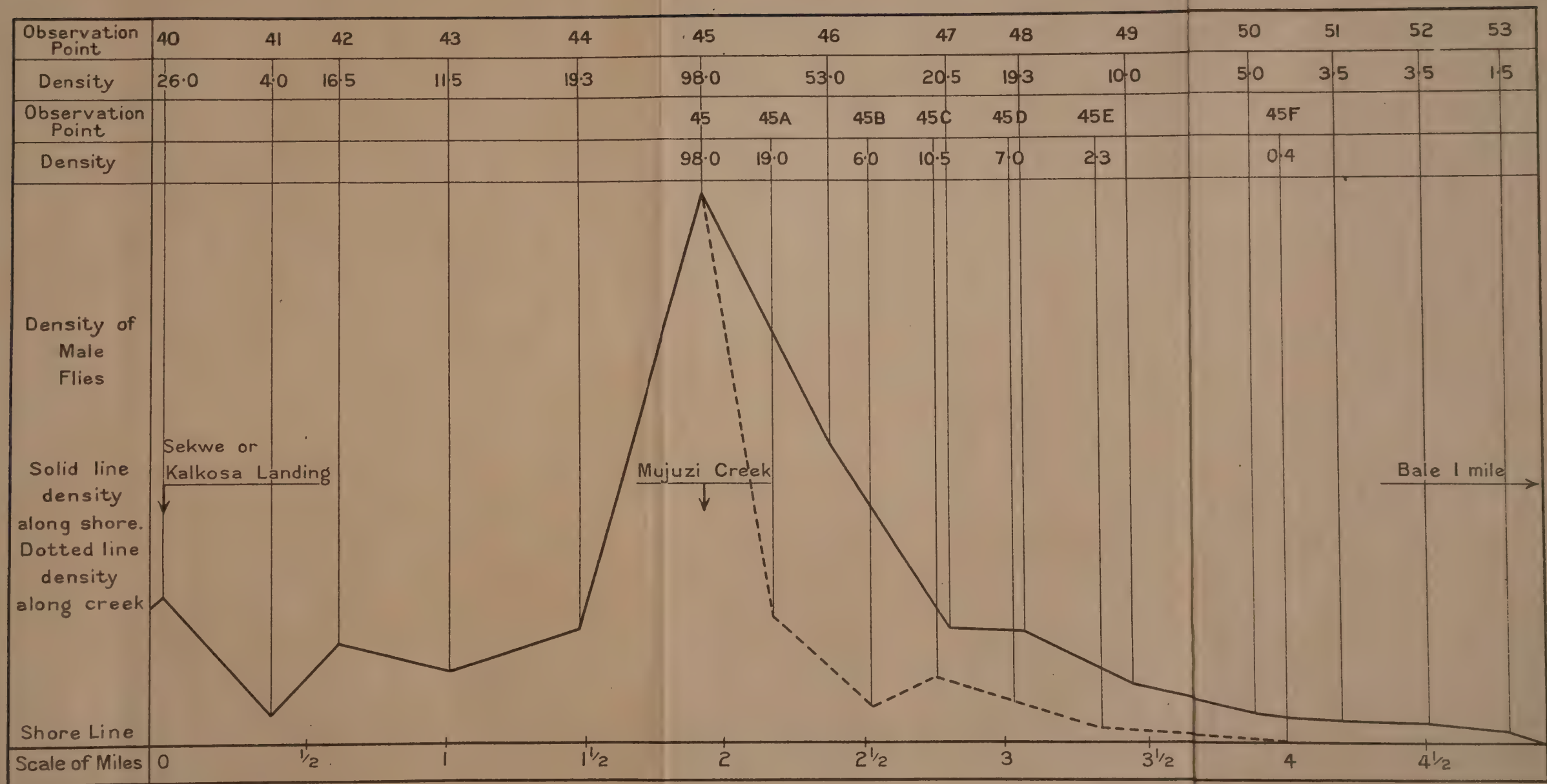


Fig. 5. Fly survey of mainland shore from Kalkosa to Bale, Buddu, showing inland spread of fly on Mujuzi Creek.



V (g). **The Sex Ratio at Points where Range is extended inland.**

In the records of catches at inland points which have been given in the preceding paragraphs a very significant feature is the falling off of female percentage coincidentally with the falling off of male density, as distance from the water point increases.

This is notable in the catches on Bugalla Island (Table XVIII), at Dumo Point, on Bujaju Peninsula, and on Kitebo Peninsula (Sect. V (e)). On Bujaju and also on Manene Island the male density was greater inland, but the female percentage strikingly lower. On Bukassa Island male density fell and female percentage remained the same, with no serious exception. The Mbugwe hill-top colony is the one striking exception, and this is also unique in being, apparently, quite independent of colonies along the shore and entirely different in this respect from the infestations at Dumo, Bujaju, Kitebo and on Bugalla Island, which are extensions inland of shore colonies.

This same phenomenon has been noted repeatedly at other points on Bugalla Island, where collections were made at distances of 500 to 2,000 yards inland, and the whole series of observations falling into this category stand in the sharpest contrast to the rule that applies along shore (so well illustrated by the curves in figure 4, p. 372) that female percentage rises as the distance from the centre of infestation increases and male density decreases. And it stands, perhaps as the best bit of other than purely empirical evidence, in proof of the effect of food supply or distribution of host animals upon inland range of fly.

The shelter on Bugalla Island, for example, or at Kitebo, is in every respect as good and attractive to the flies as on the foreshore. Food is better, and more abundant. It is only the protection afforded by the breeding grounds that is lacking to make the inland conditions of life entirely favourable.

TABLE XX.

Mujuzi Colony.				Kitebo Colony.			
Dispersion forced, by hunger, into an intolerable environment.				Dispersion induced (inland) by superior attraction of environment.			
Distance of observation point from colony centre.		Male density.	Female percentage.	Distance of observation point from colony centre.		Male density.	Female percentage.
0 yards	.. ..	98.0	45.3	0 yards	.. ..	44.5	54.3
700 "	.. ..	53.0	49.2	200 "	.. ..	29.0	49.1
1,300 "	.. ..	20.5	64.0	700 "	.. ..	20.0	37.5
1,700 "	.. ..	19.3	72.7	1100 "	.. ..	20.0	27.2
2,300 "	.. ..	10.0	80.8	1500 "	.. ..	6.5	23.5
2,900 "	.. ..	5.0	88.8				

The fly cannot breed inland, and hold its own numerically, on account of lack of good breeding places; but there is continual inland dispersion of flies from the colony centres at the breeding places on the foreshore, induced by relatively better or more food and equally attractive shelter. The flies are drawn away from the



colony centre, or centres of infestation, by more attractive conditions elsewhere. In the colony at Lutoboka Bay (fig. 4) or at Mujuzi Creek (Sect. III (e) ) dispersion is, on the other hand, forced, and the flies, instead of being drawn outward by a superior attraction, are forced outwards into a relatively repulsive or intolerable environment by the stimulus of hunger. In this latter case female percentage tends to soar as male density falls; in the former male density and female percentage fall together, as shown in Table XX. And it is certainly superior food in combination with equally attractive shelter which explains inland dispersion in all the cases that have come under observation, except inland from the lake along the banks of the Mujuzi and a few other creeks, which is comparable to dispersion along the shore of the lake.

## VI. HOSTS AND HOST PRÉFÉRENCES OF *Glossina PALPALIS*.

### VI (a). Methods of Studying Hosts and Host Preferences.

These methods were used for the study of hosts and host preferences of *Glossina palpalis* :—

- (1) Experiment. The animals were tethered along fly-infested shore (see Sect. VI (c) ).
- (2) Approach and observation. Wild and domestic animals were approached and the behaviour of fly toward them was observed under entirely natural conditions (see Sect. VI (d) ).
- (3) Shooting. When possible, wild animals were shot in the fly belt at hours when flies were active. If the animal falls without running the flies which have been following may linger by it for a time, and some of them will usually feed (see Sect. VI (e) ).

In addition to the above the study of sex ratio, as affected by the density of favoured hosts, affords an opportunity for securing supplementary or confirmatory data (see Sect. V (g) ).

A list of the principal animals that occur within the fly belt, together with methods by which they were studied as hosts of fly, and a summary of conclusions reached is presented in Table XXI. The list excludes many small mammals, such as rats, bats, etc., which though common are certainly of no importance as hosts of fly, and it also excludes others such as *Hyrax*, the "edible rat," and others which are rare or nocturnal and of no importance, in this region at least.

All animals which are fed upon by *Glossina*, and thus technically included amongst its hosts, are not equally favoured or preferred by it, and a broad line of distinction may be drawn between the two following categories :—

- (A). Hosts which are positively attractive and which are favoured or preferred to such an extent as to cause concentration of fly in localities that they frequent.
- (B). Hosts which are rather repulsive than attractive and which are avoided to such an extent that the flies tend to scatter and disperse from localities in which no more favoured hosts occur.

In numerous cases there is no doubt into which category an animal falls, and such are designated by an exclamation point (!) in the table. In other cases there is considerable doubt. These are indicated by an interrogation point (?). In one or two, notably that of the domestic ox (see Sect. VI (c), Experiment 3), some individual animals appear to be attractive and others repulsive.

There are two tests for distinguishing between attractive and repulsive hosts:—

- (1) An attractive host is apt to collect a "following swarm" of fly. This curious phenomenon is associated with the assembling of the sexes and is described in Sect. IV.
- (2) The range of fly—especially its range inland from the shore—is likely to be notably extended through the presence of favoured hosts. This phenomenon is discussed in Sect. V.

TABLE XXI.

*Summary of Observations on Hosts and Host-Preference of Glossina palpalis on Victoria Nyanza in Uganda.*

Animals observed in fly belts.	Methods of Study.			Conclusions.		
	Experi- ment.	Approach and observa- tion.	Shooting.	Is animal fed upon?	Is animal a favoured host?	Is range of fly affected by animal?
Crocodile ..	Yes	Yes	Yes	Yes!	Yes!	Yes.
Varanus ..	Yes	Yes	Yes	Yes!	Yes!	Yes.
Tortoise ..	No	Yes	No	Yes	Yes	No.
Serpents ..	No	Yes	No	No?	No	No.
Lizards ..	No	Yes	No	No?	No!	No.
Situtunga ..	No	Yes	Yes	Yes!	Yes	Yes.
Hippo ..	No	No	Yes	Yes	Yes	Yes?
Bush-buck ..	No	No	Yes	No??	No?	Yes??
Bush-pig ..	No	No	Yes	No??	No?	Yes??
Water-buck ..	No	No	Yes	No??	No?	No?
Buffalo ..	No	No	No	O	O	No?
Duiker ..	No	No	No	O	O	No.
Zebra ..	No	No	No	O	O	No.
Wart-hog ..	No	No	No	O	O	No.
Reed-buck ..	No	No	No	O	O	No.
Monkeys ..	No	Yes	Yes	No?	No!	No.
Otter ..	No	Yes	Yes	No?	No!	No.
Mongoose ..	No	Yes	No	No?	No!	No.
Hyaena ..	No	No	No	O	O	No.
Leopard ..	No	No	No	O	O	No.
Birds ..	No	Yes	No	No?	No!	No!
Man ..	Yes	Yes	No	Yes!	No!	Yes.*
Ox ..	Yes	Yes	No	Yes	Yes?	No?
Pig ..	Yes	No	Yes	Yes	Yes	Yes.
Goat ..	Yes	Yes	No	Yes	No!	No.
Sheep ..	Yes	No	No	Yes	No!	No.
Dog ..	Yes	No	No	Yes	No!	No.

\* Human presence affects range of fly negatively.

O. No evidence either way: animals rare or uncommonly seen by day.

It is important to know into which category any given host species falls, if squarely in either. It is certain that a repulsive host will not attract a "following swarm," and notes on observations of such swarms in association with any particular host are valuable in doubtful cases.

There are two host species, crocodile and *Varanus*, which form, apparently by themselves, a category of most favoured hosts. They are not only most attractive to fly, but the most favoured and best protected breeding grounds of the fly are frequently identical with either (a) spots selected by crocodiles as its own breeding grounds, or (b) spots selected by *Varanus* as a basking ground. (The female crocodiles habitually frequent their breeding grounds, and bask over the spot where their eggs are buried.)

On this account *Glossina palpalis* becomes something like a specific parasite of these reptiles, suggesting not distantly those domiciliary parasites that do not live on the body but in the nests or domiciles of their hosts, and which are specifically adapted to such a mode of life.

#### VI (b). The Habits and Habitats of the Hosts of *Glossina palpalis* in the Region of Victoria Nyanza.

The following very general notes and observations are drawn up with the idea of indicating the practicability of controlling the fly through extermination of its hosts. No proposition of this character should be considered, however, without also considering the data presented in Sect. II (d).

##### *Crocodile.*

Crocodile is undoubtedly the most important host of *Glossina palpalis* in this region. It is common nearly everywhere, on islands and mainland alike, and on or off rocky, marshy, clay-banked, sandy and gravelly shores. It is excessively numerous at times along certain reaches of marshy or papyrus-fringed shore (notably on certain floating islets north of the island of Bunjako where in August 1915 dozens and scores were seen basking together), but it cannot breed in such places. These are its feeding grounds, and individuals frequenting them must go, in some cases considerable distances, in search of the sandy or gravelly places in which alone they deposit their eggs. Much frequented breeding grounds were found—notably on the mainland in that district of Buddu known as the Swamba, and on certain islets, notably that known as Dwavannu, which lies just off the southern tip of Luambu Island, where nearly a score of occupied "nests" were found in July 1915.

The females brood daily for long periods over the precise spot where their eggs lie buried, and at such times are especially exposed to attack by *Glossina*, and provide for it a regular supply of food.

Neither breeding nor basking spots are very far from the shore; perhaps never more than 100 and rarely more than 50 yards. In consequence inland range of the fly is not affected by this host, as it may be by *Varanus*.

If it were deemed desirable to reduce the numbers of these reptiles, it could probably be done by placing a small bounty on their eggs or by locating all the favoured breeding places and making regular rounds of egg destruction. In German East Africa, I was informed, a bounty had been placed on eggs as a measure for reducing the density of *Glossina*. But such measures, to be really effective, ought to include the lake as a whole, for the animals undoubtedly move about considerably in search of feeding and breeding grounds.

They are not ordinarily hunted by the natives, who make no use of either flesh or skin, and who, though they detest the animals, will not take the trouble to destroy their eggs when found. Depopulation, the natives assert, has had no effect on the numbers of crocodile infesting the islands. They are probably almost unmitigated vermin.

#### *Varanus.*

*Varanus*, or the monitor lizard, is second only to the crocodile in importance as a host for *Glossina palpalis*. It is distributed on and near the rocky shores of islands and mainland. It is much more at home on land than the crocodile, and may wander so freely and to such considerable distances inland as to affect the range of the fly notably (see Sect. V (d)).

Few animals enjoy a greater diversity of purely animal food. Its excreta, sometimes abundant in much-frequented basking grounds, show it to feed largely on molluscs, both terrestrial and aquatic, and very freely on the fresh-water crabs that often abound under stones in shallow water. An abundance of crabs is sure to attract great numbers of *Varanus*, and nearly always, except on small and poorly sheltered islets, an abundance of *Varanus* is correlated with abundance of tsetse. But the reptile also feeds freely on insects, both aquatic and terrestrial, including among the latter such unsavoury types as cockroaches and scavenger beetles; fish and other small vertebrates, including certainly snakes and frogs; the eggs of birds, and also (so it is said) eggs of crocodile.

It domiciles itself in burrows which it excavates in sandy soil, in crevices of rocks and, quite commonly, in termite nests. Usually there is a well marked basking spot near at hand, and there occur quite frequently the breeding places of tsetse.

Its own breeding places are variously described, and declared by some European observers, positively, to be in old termite nests. But it appears more probable that they are in large mounds of earth and debris thrown up by the animals, but not watched over by them. These curious mounds are common, but of those excavated none were found occupied. The tsetse is only by chance associated with its host at these (assumed) breeding places, and there is no coincidence between the location of them and the haunts or breeding places of fly.

On certain islands and islets, notably Manene and Dziru, *Varanus* was found so commonly that an average of four or five would be flushed per hour of hunting. Such abundance, the natives assert, was unheard of previous to the depopulation of the islands, and undoubtedly the species has increased notably, and the tsetse with it. They are so eagerly hunted by the natives, partly for their flesh, but especially for their skins, that their numbers would certainly be reduced if the islands were repopulated. The skins are so highly prized—for making musical instruments—that it is doubtful if any reward or bounty would lead to the destruction of much larger numbers.

#### *Tortoise.*

No species of tortoise (or of turtle) is at all commonly encountered in this region. Therefore, though tortoise is freely fed upon and apparently a favoured host it is of insignificant account in this particular region. Elsewhere it might be of prime importance as a factor in *Glossina* bionomics.



*Serpents.*

Serpents are not commonly encountered, except, perhaps, on a few islets (notably Tavu, where a cobra was unusually numerous) and on certain sandy plains much frequented by a small earth-coloured snake. Of those observed, a python and a puff-adder seemed most likely to serve as hosts of tsetse, but both were so infrequently seen that no python and only one adder was observed in a fly-infested locality at hours when the flies were active.

In view of the notable proclivity of this tsetse to feed on reptiles, it pretty certainly attacks serpents, but in this region they cannot be of any consequence as hosts.

*Small Lizards.*

Small lizards of several species are very numerous in fly-infested localities, but all evidence that they are ever fed upon is negative. Certainly they are of no importance as hosts.

*Sitotunga.*

Although usually accounted a rare species, this antelope is easily third in importance among the hosts of *Glossina palpalis* in the region under consideration. On the mainland its range is restricted by the leopard or human hunters to marshy areas, either forested or overgrown with reeds, grass or papyrus, and to a zone of varying width (maximum observed about 2 miles) surrounding these protected areas.

It is possibly unique (together with other "species" of its subgenus) amongst antelopes in that it swims well and takes voluntarily to the water. This permits it to occupy islands where no other antelope occurs, and it is the only species occurring on any of the islands visited, except those of the Mawakota group (Bunjako, Binga and perhaps Bussi and Zinga), which lie near the western shore of the lake, and are connected with the mainland by fields of floating sudd.

Except on these sudd-bound islands there are no leopards on any that have been visited. Previous to the removal of the island population, in 1909, the antelope was restricted in insular range to the uninhabited islands of Nkose and Mwanse, and to the larger inhabited islands upon which large areas of marshy land afforded the protection required against leopard and human hunter alike. But following depopulation it was free from destructive enemies and not only multiplied with remarkable rapidity on the islands it formerly occupied (*i.e.*, those with large marshy areas), but extended its range to other islets and islands hitherto free from it.\*

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\* The following notes were made on distributions in 1915 :—

Damba Island. Originally infested, now densely infested.

Kome Island. Originally infested, now lightly infested. Spread (since 1909) from Kome to Namba and Nsadzi Islands.

Bugalla-Buninga (Sesse) Island. Originally infested, now very densely infested. Spread (since 1909) from Sesse to Fumve, Bubembe, Bunyama, Manene, Bufumira, Bugaba and Mbugwe Islands.

Nkose Island. Originally and still densely infested.

Luambu Island. Newly infested from mainland.

Bunjako, Binga, Zinga, Bussi and other sudd-bound islands all originally infested.

On these islands it has forsaken the unnecessary protection of the marshes, and assumed habits much more like those of the bush-buck on the mainland. It is most common in the jungles which have sprung up in the abandoned plantations and village sites, and is generally more common on the highlands than in its original habitat. At points it has browsed on shrubbery growing on precipitous rocky slopes which would seem to afford it the scantiest foothold. Its elongate hoofs spread so easily as not to impede rapid flight, if alarmed, even on rocky soil, and they are also worn away nearly to the length that is normal for animals that frequent rocky places.

It has developed into a most destructive enemy of many species of plants. Some of its most favoured food-plants, formerly very common, have been virtually exterminated over wide areas. There is one plant, allied to the cultivated canna, which was perhaps the most common and conspicuous of any forest herb. It formerly covered the forest floor over extensive areas on Sesse Island, growing to a height of 2 to 7 feet, and effectually concealing and protecting (in a crouching position) the antelope that fed upon it. Hundreds of acres were covered with this plant to this degree of density in the autumn of 1914, but a year later the plants had been browsed to the roots nearly everywhere. Of one species of woodland shrub, formerly very common, not a living shoot could be found in 1915. Of many species of trees, vines and large shrubs not a living seedling, leaf or young shoot within reach of the animals could be found. Areas formerly thickly massed with fern had been browsed to the bare earth and roots. And when trees fell in the forest it happened repeatedly that the animals prevented other trees from springing up, and the spaces thus became open glades.

The animals on Sesse Island were rather badly afflicted as they grew older with a mange or "scab" parasite, which seemed to be causing more trouble in 1915 than in 1914. On Damba Island this parasite did not occur. It appeared possible that it might prevent much further increase on Sesse. If not, and if nothing else disastrous supervenes, the animal must speedily adapt itself to the grazing habit, for it had reached and passed far beyond the maximum density which the island would sustain if it retained its woodland habit of browsing.

This "outbreak" of *situtunga* presents so many points of interest that it was carefully studied as a legitimate phase of these investigations, and much more was learned of it than can well be included here.

The effect on the range of *Glossina* of the increasing numbers of *situtunga* has been already described in Sect. V (c). The further effects are bound to be profound if increase continues. There are certain islands (notably Bunyama) where density of fly was well below the average in 1914-15, but where conditions are very favourable to rapid increase of the very small herds of *situtunga* then domiciled upon them, and also such as to make spectacular increase in density of fly almost a certainty if the antelope increases.

The animal is assiduously hunted by the natives for flesh, skin and horns. As already noted, they had either exterminated or prevented establishment of the species on islands devoid of the specific protection afforded it by marshy tracts, and, in time, they would pretty certainly exterminate it again if the islands were repopulated. To exterminate it from the great fields of sudd which are permanently anchored

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in the more protected bays and channels of islands and mainland would doubtfully be possible; nor would it be necessary, for these tracts are beyond the range of tsetse.

It can exist despite beasts of prey and European or native hunters in such natural protection, and requires no additional legal protection to save it from extinction; and under such conditions it is harmless. But on the islands where leopards are absent, it is absolutely to be classed as vermin wherever a human population exists or may exist.

### *Hippopotamus.*

Hippopotamus is generally distributed and, for an animal of its size, common nearly everywhere on the island and mainland shores. It stands fourth in importance among the hosts of *Glossina*, but is of much less importance than its numbers might imply, because of its habits. There are isolated individuals and small herds (herds of more than 15 or 20 are rarely encountered) which habitually sleep on land or with their bodies partly exposed along shore during the hours of activity of the fly, but these comprise only a small minority of the animals in this region. Those composing the large majority habitually sleep in deep water, and are very rarely seen on land or near enough to it to be reached by the fly during hours of its greater activity.

In a very few cases, where herds or individuals habitually repaired to some small islet or isolated peninsula to sleep by day, the density of tsetse appeared to be greater than would otherwise have been expected. But it is improbable that the effect of the extermination of this animal on range and density of fly could be easily measured or appreciated. At all events it is only those particular individuals or herds that sleep on or close to shore which are of any account in this connection.

The animals have not increased in numbers according to some natives, and have done so according to others, as a result of depopulation. They were formerly hunted, not very successfully, for flesh and skin, and also as pests, for they may be terribly destructive to plantations. On many islands it was necessary to protect plantations from their ravages by deep ditches on the water side, and sometimes on all sides.

Probably the most pronounced effect produced by the presence and activities of these animals on *Glossina* is that they keep open and closely cropped considerable spaces on shore, especially in the old plantations. These open spaces or grazing grounds are sometimes two miles or more inland, with hard beaten trails leading to landing places on shore. They are also favoured haunts of situtunga on the islands and of bush-buck on the mainland, and since they are usually in localities where the soil is fertile, they are generally banked about with thickly massed vegetation which affords ideal shelter for tsetse. Many points along shore, or inland on the islands overrun with pig, situtunga or *Varanus*, are thus made attractive to tsetse, which would otherwise be covered with vegetation of an unattractive or positively repulsive type.

### *Bush-buck.*

Bush-buck is common nearly everywhere along the mainland shore and on the sudd-bound islands of Bunjako and Binga. It is by its habits and habitat much less suitable than the situtunga as a host for tsetse, for its best natural protection is found in the thick tangles of shrubbery and vines that grow in dry and rocky places where sylvan or jungly vegetation will not flourish.



Evidence concerning its status as a host of tsetse is conflicting ; possibly it is to be ranked fifth in importance of the wild hosts in the general region.

It is hunted by the natives, but less assiduously than situtunga, and is the most persistent of the antelopes, except situtunga, found in this region. It is said to have increased considerably in the depopulated belt ; certainly it has found favourable conditions of life in many of the deserted plantations and village sites along shore.

#### *Bush-pig.*

The bush-pig ranges with bush-buck and is about equally common. Its preferred habitat is the jungles that grows in marshes which are not too wet, or on hills which are not too dry, and which are its natural protection against leopard. It is by its habitat no very suitable host for tsetse, but it may tie with bush-buck for the position of fifth in relative importance.

It is assiduously hunted by the natives, both for its flesh, and as a major pest of plantations. It is properly classed as vermin from every point of view, but as long as its natural protection is provided, it will doubtless defy native and European hunters, and beasts of prey alike successfully.

The natives aver that its numbers have increased notably as a result of depopulation.

#### *Water-buck.*

There is no water-buck on any island, but at certain points on the mainland it has become very common as a result of depopulation. No evidence associating it with tsetse was secured, but its numbers appear to be increasing rapidly in the depopulated zone and it might easily become a host of some importance.

The natives positively assert that it was formerly unknown in certain localities—the peninsula of Gova especially—where it is now common and increasing.

#### *Zebra.*

A few zebra are running with herds of water-buck on Buganga and Kiteba peninsulas. The natives assert (positively) that it was formerly unknown ; in fact, they showed complete scepticism concerning its present existence on the shore, until visually convinced.

#### *Wart-hog.*

Wart-hog has come into Buganga peninsula along with zebra and water-buck. The natives assert that it was unknown before depopulation, but it is as yet very rare.

(The return of these animals to territory from which they had been exterminated by the natives illustrates well the effect of native population on game, and indirectly, perhaps on tsetse.)

#### *Reed-buck.*

Reed-buck is a rare species in or near the fly belt and finds its best natural protection in vegetation that is positively repulsive to tsetse. It is of no consequence whatever as a host.

#### *Duiker.*

A small duiker, of unknown species, was seen in some numbers on the peninsula of Bunjako. Its habits keep it well away from tsetse, so far as observed.



### [ Buffalo.

Numerous herds of buffalo, said to be increasing, range over much of the mainland shore, and others exist on the sudd-bound islands of Binga and Bunjako. The animals come to the shore itself, but the herds keep well together and each ranges over a considerable territory, so that despite the number of animals, they do not afford an at all constant or regular supply of food for tsetse. A herd may remain for several weeks without coming near the shore, and then for a week or two range nowhere but along it.

It is believed that buffalo would be a favoured host of fly if it were less inclined to wander, but no evidence whatever could be secured.

### Leopard.

Leopard is of very great importance in the bionomics of tsetse as a deprivative enemy, for it is a major factor in controlling the range and density of bush-buck, situtunga, bush-pig and perhaps other hosts of the fly. As such it is discussed elsewhere.

It is very doubtfully a host itself, for though common enough in the fly belt, it is extremely seclusive by day.

It has probably increased with the game, and its range has been extended since depopulation to include the islands of Bussi and Zinga. Formerly it occurred only on the mainland and the sudd-bound islands of Bunjako and Binga. Bussi and Zinga Islands were not completely sudd-bound, but were separated from the mainland by a narrow open channel, used in canoe traffic. With cessation of this traffic these waterways were allowed to become choked—permanently unless the Government reopens them—and the leopards promptly crossed to the islands. The channel between Bussi Island and the mainland was the first to close, and the leopards crossed and increased to greater numbers (as evidenced by tracks and excreta) than in any other district visited. The channel between Zinga and the mainland was not known to be closed until in August 1915, when excreta of leopard were found on the island—once only seen in some five days spent in fly survey—and on investigations the channel was found choked.

### Monkey.

The common *Cercopithecus* ("green" monkey) occurs everywhere in the fly belt on the mainland, and on most of the larger islands. On the islands, in the absence of leopard and man, it is usually much more numerous than on the mainland. It was hunted as a pest by the natives and is said by them to have increased. An impression, not confirmed by actual study, was to the effect that the animals on different islands were developing into fairly well marked local varieties.

The animal appears to be consistently avoided by tsetse, and despite the facts that the flies are known to be pathogenic towards monkeys (of this species) on several of the islands, and that the monkeys forage freely along beaches densely infested by fly, they take no visible harm. Their numbers appear to be limited only by the amount of food available.

Other monkeys occur in the fly belt on the mainland, but they are more strictly arboreal. A lemur occurs on Bunyama and perhaps other islands.

*Small Mammals.*

Otter is very common on the islands; mongoose on certain islands; "edible rats" on Sesse (Bugalla) and perhaps others; *Hyrax* on Sesse; civet cat on Sesse; rats (in excessive numbers, sometimes) on many islands; and one or two other small mammals were observed. None are of the slightest account as hosts of tsetse, so far as any evidence even remotely indicates.

Fruit bats, including a large "flying fox," are characteristic of the island fauna, on account of the great quantities of wild figs that abound along rocky shores. The smaller species sleep suspended from low bushes in such a manner as to expose themselves to tsetse, but there is no shred of evidence that they are ever fed upon.

*Birds.*

A very conspicuous feature of the island fauna is the excessive abundance of shore birds: cormorants of two or three species, and darters. They breed in low bush along the shore and roost in great numbers on trees and (frequently) on low rocks, which bring them within easy reach of tsetse. The flies must occasionally feed upon these birds, but every bit of evidence which could be secured was to the effect that they are of no importance whatever as hosts. They outnumber other large birds occurring along the shore.

These others include egret, heron, ibis, crested crane, open-billed stork, saddle-billed stork, whale-headed stork (or shoe-bill—not uncommon in certain environments), Nile goose, spur-wing goose, and a few others which are potential hosts of the fly. But none, apparently, are fed upon except, possibly, in emergency.

*Domestic Animals.*

Oxen and goats are occasionally to be seen herded on the borders of the fly belt, as at Entebbe. Formerly oxen, goats, sheep and dogs were domesticated by the islanders and, despite constant contact with tsetse, appear to have done very well. There appear to be no cattle ticks on the islands at the present time, and before depopulation not all the disease-bearing ticks were present, according to available evidence. This and the absence of beasts of prey make the islands highly favourable for breeding of live-stock.

Domestic pigs were introduced to the islands by Europeans. A few escaped into the bush and were left when the islands were depopulated. They increased to excessive numbers, which were latterly reduced through unknown causes—possibly superabundance and famine. They have adapted themselves well to wild life, and have habits very suggestive of the bush-pigs (not in the least like wart-hog) on the mainland. But they would fare badly in open competition with the wild pigs, for their efforts to uproot the earth are relatively puny and bush-pigs will secure food where domestic pigs might starve.

On the one island where they occur abundantly (1914-15) they are favoured hosts of the fly, and responsible for its notably wide dispersion, if not greater density. They could doubtfully exist in the wild state in competition with bush-pig and might not be able to escape leopard, but on the islands they thrive so exceedingly well in the bush that they are to be classed as vermin, and ought certainly not to be introduced into any island unless strictly confined.

Sheep and goats are not at all favoured hosts of tsetse; the status of the domestic ox is somewhat doubtful, but probably differs greatly from time to time and place to place.

### *Man.*

Previous to the sleeping sickness epidemic all the larger islands were permanently inhabited, and fishing camps or temporary villages were located in many of the smaller ones. The mainland was also well populated, and temporary fishing villages or camps occupied by fishermen were located on reaches unfit for permanent habitation.

About 1900, the population of Buvuma Island and adjacent parts of the mainland was decimated by famine, accompanied by the outbreaking epidemic of sleeping sickness, which latterly spread into Buganda and the Sesse Islands, to the westward. In 1907 a belt along the mainland shore was evacuated by the natives at the advice of the Government, and two years later the islands were similarly depopulated. Thereafter, except at the lake ports for steamers, which were protected by local clearings, the whole fly belt was a proscribed zone, into which few natives or Europeans were authorised to enter. This zone includes all the islands (except the western shore of Bussi) and a two mile belt along the mainland shore.

Notwithstanding this proscription, man continued to come into measurably broad contact with tsetse-fly. Although the clearing at the open ports reduced density of fly to a perfectly innocuous minimum, they did not exterminate it. With enough patience I could always find tsetse in the Botanic Gardens and at certain other spots in Entebbe. Density was very low—not more than 0·2 or 0·3 by the standard adopted herein for comparative measurement—but considerable portions of Entebbe township lay within the range of the species, and a large population lived in very narrow contact with the fly.

At other open ports, notably at Bukakata, larger portions were included within the fly belt; density of fly was greater, and the local population came into broader contact with it. At Bukakata the population was very small, but it lived very broadly in contact with a not inconsiderable infestation.

Poaching within the proscribed area was, at points on the mainland, rather flagrant, and some of these points were very badly infested. The reach of shore covered by the northern spread of the Mujuzi colony (p. 387), which is the very worst infestation discovered, was, strangely, a favourite haunt of poachers. No less than 22 discarded or hidden fish-traps were found along some two miles of shore. Man was by no means a rare or uncommon host of tsetse at many points covered by the fly survey.

The islands were much less freely visited by poachers, especially after my fly survey was begun, but those nearer the mainland showed many traces of illicit occupation, most of them however old.

Taking the mainland only, man was about as frequent a visitor in the fly belt as water-buck or buffalo.

# VI (c). Experiments with Animals under Constraint to determine Host Preferences of *Glossina palpalis*.

## 1. Comparison between Goat, Pig, Varanus and Man.

This experiment was made on Lugazi Island in December 1913. Mention has already been made of it (Sect. II (b)). The animals were exposed as equally as possible along a bit of beach. The goats were native stock and full-grown; the pigs of European stock and only about one-quarter grown; the *Varanus* were newly caught, one being full-grown and the other about half.

The bites inflicted upon man were counted for comparative purposes, but the comparison is not exact, because only the flies actually engorging on the animals were counted, and some bit without engorging. The goats appeared to have been bitten several times, and each time prevented the fly from feeding. The complete immunity of goats and man, in so far as engorgement is concerned, is due to the same cause—an instinctive movement in self-protection which causes the fly to desist from attack. Neither were immune from being bitten, and bites on goats were probably about as numerous as on man.

TABLE XXII.

*The Relative Attractiveness of Varanus, Goat, Pig and Man to Glossina palpalis.*

Host.	No. of hours exposed	No. of bites inflicted.	No. of bites per hour.
Varanus .. ..	24	60	2.50
Pig .. ..	32½	1	.03
Goat .. ..	76	0	.00
Man, African ..	38	1	.03
„ European ..	202	5	.02

Infestation by fly at the point where the experiment was made was :—Male density 6.0; female percentage 15.5.

The strong preference displayed by fly for *Varanus* over the other hosts was confirmed in subsequent experiments. The results with pig proved untrustworthy. It was later discovered (p. 381) that this animal is sometimes, at least, a favoured host.

## 2. Comparison between Goat, Varanus and Crocodile.

Two goats, one *Varanus* and one crocodile were used in a short experiment on Kimmi Island on the 27th January 1914. The crocodile was young and active, and between 3 and 4 feet in length. The *Varanus* was slightly larger. All animals were exposed as equally as possible. The crocodile first, and soon after the *Varanus*, became intractable, apparently because of the swarms of flies which assailed them, and the experiment had to be discontinued.

The infestation of this island at this time was :—Male density 24.3; female percentage 57.5.



TABLE XXIII.

*The Relative Attractiveness of Varanus, Crocodile and Goat to Glossina palpalis.*

Host.	No. of hours exposed.	No. of bites inflicted.	No. of bites per hour.
Varanus .. ..	2	98	49.0
Crocodile .. ..	1½	40	22.8
Goat .. ..	4	3	.7

The comparison between *Varanus* and goat is believed to be a fair one. That between *Varanus* and Crocodile is not so fair, because of the small size and greater activity of the crocodile. Both are favoured hosts, and about equally so.

### 3. Comparison between Ox, Sheep and Varanus.

This experiment was conducted in April 1915 on the Peninsula of Nubiru, on the mainland. Two native sheep, both full-grown, were used, and three young bulls about half-grown. One of these was an apparently pure-blooded Ankole (*Bos aegypticus*); the second was of a strongly marked zebu or Indian type, with fully developed hump and other characteristics; the third had the outward appearance of some nondescript European breed, and was probably a half-breed. Special care was used to expose the various animals as equally as possible. The results are summarised in Table XXIV.

TABLE XXIV.

*The Relative Attractiveness of Varanus, Sheep and Ox to Glossina palpalis.*

Host.	No. of hours exposed	No. of bites inflicted.	No. of bites per hour.
Varanus .. ..	4	29	7.1
Ankole Bull .. ..	11	32	2.9
Indian „ .. ..	11	1	.1
Half-breed „ .. ..	11	20	1.7
Sheep No. 1 .. ..	11	1	.1
„ No. 2 .. ..	11	0	.0

Infestation by fly in this locality was, at this time :—Male density 5.3; female percentage 41.2.

There were two extraordinary features of this experiment, one of which is brought out in the table above: the immunity of the Indian bull to attack as compared with the Ankole and half-breed. This was entirely due to his very excitable temperament. He was intractable, and perhaps a bit dangerous, and became almost as excited under attack by *Glossina* as the sheep, which were even more intolerant of fly than the goats used in previous experiments. The Ankole, on the other extreme, was absolutely tractable and docile, and refused to become annoyed at the attack of either *Glossina* or *Stomoxys*, and the half-breed was not much different. Both these animals were covered with ticks, but the Indian would not permit even these pests, and by remarkable contortions succeeded in freeing himself of them on nearly every part of his body.

The second notable feature of the experiment was the behaviour of fly toward the bulls at different hours of the day. The experiment extended over three days. Each day the morning was dull and rainy and each day the animals were taken to the shore as soon as the clouds broke and while the vegetation was still wet. As will be seen by Table XXV the bulls were fed upon much more frequently during the first hours following the clearing, but the *Varanus* was somewhat more freely attacked later on.

TABLE XXV.

*Behaviour of Glossina towards Domestic Ox as affected by Presence of Tabanus.*

Animals.					Bites per hour inflicted during first hours following clearing of weather; <i>Tabanus</i> not active	Bites per hour inflicted during later hours; <i>Tabanus</i> active.
Ankole	Bull	..	..	..	7.3	1.1
Indian	"	..	..	..	.3	.0
Half breed	"	..	..	..	5.0	.7
Varanus	..	..	..	..	5.0	7.4

The fact that the number of flies feeding on *Varanus* increased after the first hour, instead of falling off sharply, proved conclusively that the flies were no less active or less willing to feed, and the explanation for the sharp decline in number of bites inflicted on the bulls is unquestionably due to the fact that an hour or so after the clouds broke and when the vegetation was quite dry a large species of *Tabanus* appeared and caused the animals much annoyance. Not even the phlegmatic Ankole would permit these great flies to approach it; the *Glossina* were incidentally included in the interdiction, and were effectually prevented from attacking if there was any *Tabanus* about. But no *Tabanus* or any other flies than *Glossina* attacked the *Varanus*.

These experiments were inconclusive in so far as proving the relative status of the domestic ox as a host of *Glossina palpalis*; but they conclusively showed that where such animals are concerned freedom of attack by *Glossina* is to a very large extent determined by the temperament of the individual, and also by extraneous circumstances and conditions of time and place.

The experiments were continued over several days, more in an effort to find some locality where there was tsetse but no *Tabanus*, and also in an effort to induce a "following swarm" to collect on either an ox or *Varanus*, but without result. The cattle found the *Tabanus* so annoying that it was necessary to constrain them to remain near the Lake shore at hours when these flies were active, and they were generally distributed at all points along this reach of shore. The *Varanus*, also proved intractable, and would not remain quiet in restraint. On this account it is believed, the "following swarm" (*vide* Sect. IV) refused to collect.

#### 4. *Comparison between Varanus and Man.*

On 31st October 1913 a large *Varanus* was tethered at a point on the shore of Bulago Island infested by *Glossina*. The morning was cool, and few flies were active until about 11 o'clock, when the weather cleared. It was then noted that the observer appeared rather more attractive to them than the *Varanus*.

From noon until 1.30 the animal was left alone, and on returning to it, more than 30 (perhaps more than 50) flies were resting on or near it, and many more were close at hand. Many were feeding, and about 100 were observed to engorge in the course of the afternoon.

No fly bit the observer during this period, and it was estimated that 30 flies came to the reptile to 1 that would come to him—in sharp contrast to the conditions in the morning.

This was a true "following swarm," and the only one that could ever be induced to gather on an animal in captivity or under constraint. The failure of all other experiments in this respect is believed, certainly, to be due to the uneasiness of the animal, and it was long afterwards recalled that the animal in this particular experiment had been quite severely wounded, and was disinclined to activity.

#### VI (d). **Approach and Observation of Animals in a Natural Environment to determine Hosts and Host Preferences of *Glossina palpalis*.\***

##### *Varanus.*

*Varanus* were approached on a fair number of occasions, and ample confirmation was secured of their attractiveness to tsetse as a host.

##### *Crocodile.*

Crocodile was never actually approached, for there are few animals more quick to take alarm at the sound of an intruder, and at the first alarm a crocodile—unlike many other animals—is sure to make off. But on several occasions when they have been seen to slip quietly into the water, the vegetation near the spot where they were resting has been found covered with engorged flies; on one occasion in such numbers that the small bushes nearest at hand seemed thick with red berries.

##### *Situtunga.*

Attempts to approach situtunga were singularly successful. Many of the animals on the islands had never seen man, and though the scent of him would stampede them instantly, they were not, as a rule, at all alarmed at the sight of him if he remained motionless. Perhaps a dozen in all were successfully approached.

Notes on behaviour of fly toward this host have already been presented. The behaviour of the host toward fly was rarely positive. They are phlegmatic, and very bovine in their actions, only occasionally showing signs of annoyance by a movement of the head, if flies are very persistent. An exception was a half-grown male, accompanying several adults, which displayed almost continual annoyance, with *Stomoxys* no less than with *Glossina*.

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\* See also notes on "following swarm," Sect. IV.

No large Tabanids or other large biting flies, apart from *Glossina* and *Stomoxys*, were ever seen on situtunga on the islands.

#### *Tortoise.*

Tortoise have twice been encountered on land in infested territory, and on each occasion were accompanied by so many flies as to constitute a "following swarm." The flies were seen to feed on both occasions, and in one instance the animal was very plainly annoyed, frequently brushing the flies from its head with its foot. The flies fed principally on the orbits, and the extent to which the subject had suffered from their attack was witnessed by a whitish ring surrounding each eye composed of the dried serum which is exuded in droplets by the flies while feeding.

#### *Monkeys.*

Troops of the *Cercopithecus* monkey common to the region have twice been approached closely enough to observe the movements of flies in their vicinity. The most successful attempt was on Bugalla (Sesse) Island in January 1915. A considerable troop was deployed on the beach at a point where infestation was heavy. Flies could be seen resting on rocks around which the monkeys were foraging (for crabs), but none was seen to approach the animals, nor did the latter show signs of being attacked.

When goats or sheep are driven into infested spots like this, enough flies will approach to keep them on the *qui vive*. There is no doubt that this species of monkey is avoided by fly yet more completely than sheep or goats.

#### *Otter.*

The mammalian life on the islands is so lacking in diversity (as compared with the mainland) that otter, next to situtunga, hippopotamus and pig, is the most logical warm-blooded host for tsetse. On three occasions otters were observed on land freely exposed to attack by tsetse and under conditions which would certainly have led to attack upon *Varanus*, but the flies paid no attention to them.

#### *Mongoose.*

A large mongoose is common on certain islands—notably Kitobo, where more were seen in a week's time than on all other islands together. It has a habit of basking in the sun, selecting a spot where its ground-colour (much like dead leaves) harmonises completely with its surroundings. By its habits it is freely exposed to attacks of fly, but on several occasions when animals basking in fly-infested spots have been flushed, no fly has been observed.

#### *Domestic Animals.*

Cattle were more or less regularly, and goats occasionally, herded on the borders of the fly belt near Entebbe, and fly was occasionally seen on the former. But it was especially noted (after the experiment with cattle at Mbiru described in the preceding sub-section) that the presence of other flies—and others were usually present in very much larger numbers than tsetse—reacted upon the cattle, and their behaviour upon that of *Glossina*, to protect them measurably from attack.



It is one of the most important traits of *Glossina* to be, perhaps, the quickest of all biting flies to detect and evade retaliatory movements on the part of its hosts. There is no large biting fly known to me which does not possess this self-protecting trait; otherwise stated, there is no large biting fly the behaviour of which I have observed that will habitually press its attack upon an aroused and unwilling host regardless of consequences to itself. Recently I have been studying the behaviour of Tabanids of various species toward animals of many kinds in the Washington Zoological Park, and while they are much more persistent than *Glossina*, they clearly "know when they have had enough" and desist from pressing an attack on an unwilling host. It is this same trait that is developed to a conspicuous degree in *Glossina palpalis* which explains the great relative immunity of so many animals, including probably man and monkey. It is doubtful whether it is nearly so strongly developed in *Glossina morsitans*.

### Man.

Life in the fly belt affords a perpetual opportunity to observe and study behaviour of fly toward the human host, and the important reactions of the host toward the parasite.

The idea that the European is less freely attacked than the native is apparently baseless, in so far as the original movement of the insect is concerned. The European is more quickly stimulated to retaliatory action—of a purely instinctive and almost uncontrollable sort—than *some* natives, but there is almost or quite as much difference between men as between the Indian and Ankole bulls used in the experiment at Mbiru. Some of my porters or boys would react to the first approach of a tsetse, and these the flies left severely alone, unless there was very great scarcity of other food. Others of my canoe-men were, in contrast, extremely apathetic and phlegmatic, and would not react to anything short of a severe bite,\* and such as these were very frequently bitten. Moreover men of phlegmatic temperament would calmly compose themselves to sleep squarely in line with the stream of passing flies along shore, rather than miss recall to the canoe for foraging expeditions, though they might have escaped the fly by going a hundred or two yards inland; and on one occasion something suggestive of the nucleus of a "following swarm" was observed collected upon the sleeping forms of the lazier members of the canoe's crew who had thus exposed themselves to attack.

Next to sleeping men, men engaged in an absorbing occupation are most liable to attack. I estimate to have been bitten 1,500 times in 18 months, and if from this total is subtracted such bites as were inflicted in localities when both male density and female percentage were high, and when the writing of field notes would hardly be undertaken, it is probable that a majority of these bites were inflicted while I was note writing. This was my only absorbing occupation in the fly belt, but the men had many—repairing canoes; manufacture and repair of fishing tackle; cleaning of fibre (for lines and cordage), etc. In such cases the busiest—not, as above, the laziest—men came in for freest attack.

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\* The bite of *G. palpalis* may be absolutely painless, or it may be almost stinglike in sharpness, or anywhere between.

But most frequently of all, men were bitten while paddling the canoe. If the landing were infested, a number of flies—sometimes from badly infested landings a dozen to twenty—would follow the canoe from shore, and once fairly away from shore would be very loath to leave it. And these flies, seemingly because there was nothing else to do, were remarkably prone to feed\*—not at first, but some time after the canoe had left the land. The work of paddling is purely mechanical and rhythmic, and not in the least absorbing except for the steersman, but it is of a sort that cannot well be interrupted to ward off a hovering fly. Consequently the flies would be left undisturbed until one actually bit, when the paddler, if he felt it, would interrupt his work to drive it away. The fly would then pass to another man, and the process might be repeated many times. I have actually seen five men bitten in quick succession by a single fly, and it is not at all easy to follow the movements of a fly in a crowded canoe.

The engorged flies curiously pass forward in the canoe—against the wind of passage—and will cluster on the prow of it. On one occasion, while rounding a densely infested point of land on the Buddu shore and passing too closely in doing so, a swarm of flies assailed the canoe, and in due course a cluster of eight, fully engorged, had formed on the prow.

This rounding of fly-infested points too closely is even more conducive to attack upon man than the departure from fly-infested landings, for if the canoe skirts the shore for any considerable distance it may gather flies in large numbers, and carry them out to sea.

I have not seen flies come to a canoe much, if any, more than a hundred yards out, and not many will come to one over fifty yards out; but at forty or fifty yards a perfect swarm of flies may make a whirlwind descent.

All things considered, the hunter or forager is probably most immune to attack by tsetse of any individual, for his senses are keyed up, and he is wide-awake and conscious of little things without being physically absorbed in any occupation that deters him from warding off a menacing fly. Certainly I have been bitten least frequently while engaged in hunting or in patrolling the shore in fly survey work, always intent on whatever might be taking place in the vicinity.

As noted of cattle, the relative susceptibility or immunity of man and of individual men to attack is very largely a question of temperament, and of conditions and circumstances of time and place—not forgetting to include among these the relative abundance of other food than human blood.

#### VI (e). **Hosts and Host Preferences of *Glossina* as determined by Flies found on Animals shot in Fly Belts.**

*Crocodile*.—Island of Tavu, 13th September 1915.

A crocodile between 9 and 10 feet in length was shot in such manner as completely to paralyse the body but not to stop circulation of blood (these animals will live and move the body vigorously for an hour or more after a brain shot; this

\* It is a curious trait of *Glossina morsitans*, and probably also of *palpalis*, to feed in confinement when they would not if unrestrained. Freshly captured, caged flies will usually feed promptly on the body of an animal pressed against the wire screen, when they would most certainly not have fed if uncaught.

one was shot through the neck vertebrae, and did not bleed, as when shot through the brain). "Following swarm" present, estimated at over 100 flies. In course of one hour 18 flies fed. No flies bit or annoyed the observer. Infestation at this point:—Male density 41.0; female percentage 12.2.

*Situtunga*.—Island of Sesse (Bugalla), 4th October 1914.

A nearly full-grown male was shot in an old plantation on a hill top about 1,000 yards from water at 5.30 p.m. Small "following swarm" of 22 flies present, of which 6 fed. None annoyed observer. Infestations at this point:—Male density 12.0; female percentage 8.0.

*Situtunga*.—Island of Sesse (Bugalla), 10th October 1914.

Large male shot in old plantations about 500 yards from shore at 11.0 a.m. Day dry, but overcast and conditions unsuitable for fly to be active. Following swarm of from 30 to 40 flies, of which 11 fed. None annoyed observer. Average number following observer through this region (while hunting) between 2 and 3. Infestation at this point (taken after the weather had cleared and flies became more active):—Male density 15.3; female percentage 23.3.

*Situtunga*.—Dumo Point, Buddu, 13th June 1915.

Adult female shot about 2.30 p.m. in thick swamp of raphia palms. There were 3 flies following her. Distance 400 to 500 yards from shore, which is marshy and thinly infested. Density at this point (4 boy-hours spent there) nil.

*Bush Pig*.—Dumo Point, Buddu, 13th June 1915.

Adult male shot about 9 a.m., within 100 yards of spot where *situtunga* noted above was shot in p.m. No fly.

*Bush Pig*.—Dumo Point, Buddu, 17th June 1915.

Adult female shot about 5.30 p.m. in guava thicket (mentioned on p. 385) 500 yards from Lake shore. No fly. Infestation at this point:—Male density 8.8; female percentage 21.4.

Altogether 9 bush-pigs were shot in or so near to fly belt that presence of fly on them would have caused no surprise. But none were shot under more favourable conditions than the two noted above. If a *situtunga* had been shot under the conditions cited in the second case, absence of fly would have caused surprise. In view of the infestation of this particular point, and of no visible cause for it except the frequency and regularity with which it was visited by bush-pigs in search of the falling guavas, considerable surprise was felt that no flies were following this animal. The evidence concerning preference displayed by *Glossina* for this host is conflicting, as in the case of bush-buck.

*Bush-buck*.—Island of Bunjako, 17th August 1915.

Three nearly full-grown males shot about 12.30 in old plantations about 200 yards from densely infested shore. No fly on animals. Infestation on shore:—Male density 26.0; female percentage 29.1. Infestation at point where animals were shot:—Density 4.5; females 39.2 per cent.



Altogether about 10 or 12 bush-buck were shot under conditions which would have made presence of fly explicable. In only one case was fly found,\* but in no case did its absence cause real surprise except in the one cited above. Had these animals been *situtunga*, absence of fly upon them would have been extraordinarily exceptional. The evidence concerning preference of *Glossina palpalis* for bush-buck is completely conflicting. As in the case of bush-pig, dispersion of fly inland from water indicates bush-buck to be a favoured host, but absence of fly on shot animals indicates the contrary.

*Water-buck*.—Bugunga Peninsula, 15th August 1915.

Very large male shot about noon, grazing on edge of thicket about 200 yards from shore. Good weather, and boys were catching fly near at hand at the time. No fly on animal. Infestation at this point:—Male density 4·5; female percentage 25·0.

The evidence is negative, in view of the above notes on bush-buck and bush-pig.

*Domestic Pig*.—Island of Serinya, 15th September 1914.

Large fat female, one of two, shot about 10.30 a.m., 150 yards from shore, behind dense fringe of reeds, in open forest. Day overcast, but clearing. Large following swarm, considering conditions—perhaps 40 flies, of which many fed. Density at this point very low, but tracks of pig followed backwards led to a densely infested reach of shore 500 to 800 yards distant.

A number of pigs were shot on the Island of Bukassa under conditions almost equally favourable, but no following swarm was observed on them. In this case on Serinya the evidence secured in this manner confirms precisely the evidence presented in Sect. V (c) leaving no doubt as to the status of domestic pig as a favoured host—at least under certain conditions.

*Hippopotamus*.—Island of Buninga (Sesse), 26th July 1915.

Adult female shot about 9 a.m. It was apparently sleeping on the shore, and, aroused by approach of canoe, was cut off from the water. Body fell on land, less than 100 yards from the point where shot. Large following swarm (estimated at 125 flies), of which many (estimated at 30 flies) fed. They fed on eyelids, nose, feet and belly, and engorged freely despite the thickness of the skin—evidently on blood in the skin, if this is possible. (It occurred to me afterwards that though gorged or partly gorged flies were seen apparently feeding on the legs and belly, no flies were actually observed engorging except on the eyelids and nose.) Infestation at this point:—Male density 26·0; female percentage 22·0.

This is the one instance in which a hippo was shot (a) on land, (b) without plunging into water, (c) in a fly-infested locality, and (d) at an hour when fly was active. The conditions are not easy to meet, but this single case fixes the status of hippo as a favoured host.

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\* In this case there was but one fly and it is not certain that it was attracted to the antelope.



# VI (f). Long-shore Range and Density of Fly as determined by Food Supply on Victoria Nyanza.

*Glossina* must, of course, have food, and no other food than the blood of vertebrates is required by flies in confinement. If any other sort is ever taken, evidence or indication that it is required by the flies is entirely lacking.

Evidence is abundant and conclusive that the four most common of the large shore-loving or amphibious animals found in this region are all favoured hosts (crocodile, *Varanus*, situtunga and hippo). Evidence with respect to common game animals of the mainland (bush-buck, bush-pig, water-buck and buffalo) is negative or conflicting, but it would probably be a conservative estimate that the four favoured hosts first mentioned provide 95 per cent. of the food taken by *Glossina palpalis* on the mainland and 98 or 99 per cent. of its food on the islands (excepting the islands of Bunjako and Binga, where bush-buck, etc., occur, and Bukassa, where pig is a factor).

If this is correct, it might be assumed that complete extermination of the four principle hosts would—in the absence of man and domestic animals—cause reduction in density of infestation by 95 to 99 per cent. I think this would undoubtedly follow, if the extermination of the hosts was complete, for there are several reaches of mainland shore in the district of Buddu where absence of all host animals of favoured species from points within range or reach of tsetse from good shelter and good breeding places is specifically correlated with absence of fly. The best case of this sort is illustrated by figure 6 and the explanatory note accompanying it. Another striking case is the Mujuzi colony, which is remarkable in so many ways, and which is illustrated by fig. 5 (p. 388). This colony centres conspicuously at the point (45 in graph) where alone food is plentiful. North of the colony centre (points 46 and 47) there are good breeding grounds and good shelter, but the falling off in density, coupled with the uniquely high female percentage (p. 373), left no doubt that absence of food explained scarcity of fly away from the colony centre.

It is absolutely necessary, however, that adequate protection in the form of both shelter and breeding grounds shall be provided for the insect within reach of food; otherwise the most abundant supply of the most preferred food is valueless to the species. These conditions occur in many localities, and are described in some detail in discussions on the effect of shelter and breeding grounds on range and density of fly. Small islets, like that south of Dziru or that east of Bubembe (p. 429), may fairly swarm with crocodile and *Varanus*, and, in addition, provide breeding places of the very best, but if devoid of adequate massive shelter they are fly free, or infested only by stragglers from elsewhere.

It is wholly impracticable to attempt a presentation of general data concerning environmental conditions at the many points on the mainland and on the more than 70 islands that were wholly or in part surveyed. (It would require not less than 150 pages of descriptive matter apart from tables and graphs.) The selected cases cited in various connections must suffice, together with the conclusions drawn from a thorough study of original data in the field (November-December 1914), followed by extensive fly surveys (Sesse Islands and the Buddu and Mawakota shores)





designed in part to confirm conclusions drawn from co-ordination of data collected in the course of the Island survey, viz. :—

- I. If protection (shelter and breeding ground) is more than adequate, range and density of *Glossina palpalis* are controlled by quantity of food of preferred sorts occurring within range or reach of flies from both kinds of protection required (see fig. 6 and note following).
- II. Food, even of the most favoured sorts, is valueless to the species unless protection (of both sorts, shelter and breeding grounds) occurs within range or reach of individual flies from it.
- III. The distance separating food from protection (as it may be measured by yards) is a factor of the very first importance in determining the prevailing degree of infestation by the species.

#### VI (g). **Effect of Crocodile on Range and Density of Fly along Shore.**

The curve in the accompanying graph (fig. 6) illustrates the variations in local density of *Glossina palpalis* along a reach of four miles of shore which was surveyed in May and June 1915.

The foreshore at these points was an open sandy beach, continuous except at observation points 5 and 9, where it was cut by small creeks. Immediately behind the beach was a belt of open grass-land with a few scattered bushes—not enough to afford shelter for fly. The soil was beach sand, and this open belt or natural clearing was from 40 to 100 yards in width. Behind it was thick bush, jungle and forest, affording excellent shelter for fly; good breeding ground was almost continuous along the border of the woodland from point 1 to point 9.

Food only was lacking. There were tracks of hippo, bush-buck, bush-pig, water-buck and buffalo in the open belt, but the animals were not seen; their spoor was not fresh, and they were obviously only occasional visitors. Crocodiles and the fresh spoor of crocodiles were seen along the water's edge, but they were effectually cut off from shelter by the open belt, and beyond reach of flies.

Only at points 5 and 9, where the creeks cut through the open belt and sand beach, did the crocodiles come into range or reach of flies from shelter. At these points they found harbour in the mouths of the creeks, and basked on their banks within easy reach of the flies from shelter, and here, as the graph clearly shows, two small semi-distinct colonies of fly existed. There could be no doubt that the existence of these colonies was due to the presence of a regular supply of food, represented by the crocodiles, within range or reach of the flies from shelter.

#### VII. THE BREEDING GROUNDS OF *GLOSSINA PALPALIS*.

It is a strongly marked characteristic of *Glossina palpalis* to seek specifically protected spots wherein to deposit its larvae, and extraordinary accumulations of puparia and the empty shells of them (from which adults have issued) may be found in especially attractive situations.

To what extent the species is dependent on breeding grounds of sorts easily found, and recognisable as such, was unknown, and it was one of the principle objects of these investigations to secure positive information on this point, and in the hope that it would prove practicable to control the density of the insect by seeking and destroying its specific breeding places.



### VII (a). Breeding Grounds on Sand and Gravel Beaches.

The larva of *Glossina palpalis* is nourished by the female until full-fed and ready to pupate, and is then carried by her and deposited in protected situations known as breeding places. The most attractive breeding grounds are the deposits of clean dry beach sand or gravel that occur more or less frequently along the shore. They must be in or near to the course followed by the streams of moving flies, *i.e.*, very few puparia can be found in situations much off the course of fly traffic—and they must be shaded.

Shade may be afforded by almost anything, provided only that it is not more than two or three feet above the surface of the soil. If much higher the spot will be avoided. Vegetation, both shrubby and herbaceous, rocks, logs, stumps, etc., will provide attractive shelter from the sun. The need of it is imperative, for the larvae never penetrate more than two or three inches below the surface, and the sun striking full on the surface will kill the puparia quickly. Even in the shaded, sand-strewn caves which occur along the shores of certain islands, into which the sun never penetrates, and which are sometimes attractive as breeding places, the flies will only deposit their larvae around the edges, close under the overhanging rock, as though fearful lest the rock farther above the surface of the soil might not provide the continuous shelter required.

In especially attractive spots—if there are not too many of them—large deposits of puparia and puparium shells may frequently be found. The record "catch" which was accurately counted was made in September 1914 on the island of Zinga, beneath an old stump thrown upon the beach by some storm, and overgrown with "morning glory" vines. It required one boy 35 minutes to sift the soil beneath this bit of shelter. In a space hardly more than a yard square he found:

Empty shells	..	..	478	Rate per boy hour	814
Healthy puparia	..	..	144	„	247
			<hr/>		<hr/>
Total			622	„	1061

Relatively few accurate counts of puparia and pupal shells were attempted, for unless inordinate pains are taken, the figures mean little or nothing. There may be much or little attractive breeding ground, and if much of it, puparia are difficult to find—if little of it, they are more easy to find. The number of puparia found at different seasons of the year means nothing, for the upspringing or withering of vegetation affects the extent and attractiveness of breeding ground profoundly; and the same is true of the more or less regular fluctuations in level of the lake. The accompanying table (Table XXVI) will indicate the numbers likely to be found by expert fly boys under favourable conditions—as along the "fly beaches" (each locality except that on Tavu Island was a "fly beach").

For a time it was thought that data on the proportionate numbers of pupae in different stages of their development might be worth collecting, but after a time the idea was discarded. The healthy puparia were opened, and those showing the grey colour of the adult were classed as "late stages," while those showing no colour except on the eyes were classed as "early stages." The data of this

character collected are, in part, presented in Table XXVII. They are mainly interesting on account of the much lower percentage of late stages on the island of Kimmi in March 1914 than during the previous January. In this specific case

TABLE XXVI.

*Showing Number of Puparia of Glossina palpalis that may be found per Boy Hour in Attractive Breeding Grounds on Islands in Victoria Nyanza.*

Island.	Date.	Find of Healthy Puparia.		
		Gross.	Per boy per hour.	
			Maxim.	Average.
Tavu .. .. .	January 1914 .. ..	586	268	65.1
Wema .. .. .	February " .. ..	1775	196	34.2
Zinga .. .. .	September " .. ..	144	247	—
Damba .. .. .	February " .. ..	797	71	39.3
Yempaita .. .. .	" " .. ..	445	211	49.3
Nsadzi .. .. .	" " .. ..	133	46	16.8

TABLE XXVII.

*Showing Variable Proportions of Pupae of Glossina in Late Stages of Development, possibly indicative of a correspondingly Variable Rate of Reproduction.*

Island.	Date.	Finds of Puparia.		
		Early stages.	Late stages.	Per cent. of later stages.
Wema .. .. .	February 1914 .. ..	1228	447	26.7 %
Yempaita .. .. .	" " .. ..	267	157	37.0 %
Damba .. .. .	" " .. ..	349	7	16.9 %
Nsadzi .. .. .	" " .. ..	73	43	36.5 %
Tavu .. .. .	September 1915 .. ..	320	79	20.0 %
Karambide .. .. .	" 1914 .. ..	6	25	80.6 %
Mugogoya .. .. .	" " .. ..	12	5	29.4 %
Zinga .. .. .	" " .. ..	92	52	36.1 %
Namba .. .. .	January " .. ..	18	6	25.0 %
" .. .. .	March " .. ..	30	12	28.6 %
Kimmi .. .. .	January " .. ..	101	87	46.3 %
" .. .. .	March " .. ..	130	25	16.1 %
Total and Average of total .. .. .	.. .. .	2626	989	27.3 %
Average by Islands .. .. .	.. .. .	..	..	33.3 %*

\* This is unduly high on account of the find on Karambide, where the high percentage of late stages was due to the breeding grounds being recently abandoned by flies.

especial care was taken to make the count and test a fair one, in connection with the unusual conditions prevailing on the island in January. It was believed at that time that on account of shortage of food the insects were unable to breed at all freely, and that a high proportion of late stages of pupae would confirm this fact. Surely enough, the proportion of late stages was abnormally high—and surely enough, it was abnormally low in March when food had become more plentiful; but whether the data sustain the hypothesis is somewhat doubtful. A more complete account of the experiment is given on page 451.

The proportion of living puparia to empty shells varies extremely, and variations may be due to many causes. The normal proportions would appear to be about 1 to 5 (if there is a "normal"), but there are so many things which might explain variations from it that data are of slight value, except perhaps in special cases. The first citation in the accompanying table is such a special case. The find was made at a spot where *Varanus* had habitually basked, but there were no recent signs of the presence of the animal, and, with its abandonment of its favourite basking spot, the flies ceased to find the spot attractive breeding ground.

Of somewhat greater interest is the percentage of empty shells which have been eaten or destroyed by some predatory creature—ants, or beetle larvae—which extract the contents without completely destroying the shell. The small percentage of eaten shells and the large percentage from which the flies had issued, shown in Table XXIX, is a clear indication of the remarkable degree of protection afforded by good breeding places to the pupae of *Glossina*. The subject is discussed somewhat more fully elsewhere (p. 435).

TABLE XXVIII.

*Showing Proportion of Living Puparia of Glossina palpalis to Empty Shells found on Islands in Victoria Nyanza.*

Island.	Date.	Finds of puparia and empty shells.			
		Puparia.	Empty shells.	Total.	Per cent. of puparia.
Limnaiba .. ..	September 1914 ..	3	283	286	1.1 %
Kiuwa .. ..	February .. ..	6	456	462	1.3 %
Kimmi, Pt. 1* ..	" .. ..	17	1077	1094	1.6 %
Damba, Pt. 1. ..	" .. ..	39	1163	1202	3.2 %
Kimmi, Pt. 2* ..	" .. ..	59	1412	1471	4.0 %
Damba, Pt. 2. ..	" .. ..	797	4493	5290	11.1 %
Nsadzi .. ..	" .. ..	133	979	1112	11.9 %
Mugogoya .. ..	September .. ..	17	85	102	16.7 %
Zinga .. ..	" .. ..	144	478	622	23.1 %
Karambide .. ..	" .. ..	31	79	110	28.2 %
Tavu .. ..	" 1915 .. ..	207	344	601	34.4 %
Wema .. ..	February 1914 ..	1755	3044	4799	36.6 %
Total and Average .. ..		3208	13943	17151	18.7 %

\* Point 1 on Kimmi Island was in a cave, where the empty shells might be expected to persist indefinitely. Point 2 is the total for several finds elsewhere on the island.

TABLE XXIX.

Showing Degree of Protection against Predatory Destructors provided for pupae of *Glossina palpalis* by good Breeding Places.

Locality. Wema Island, February 1914.	Find of Empty Shells.			
	Fly emerged.	Destroyed by predators.	Total.	Percentage destroyed.
First Beach .. ..	46	0	46	0.0 %
Second " .. ..	46	5	51	9.8 %
Third " .. ..	292	7	299	2.3 %
Fourth " .. ..	318	9	327	2.8 %
Fifth " .. ..	213	3	216	1.4 %
Sixth " .. ..	521	11	532	2.1 %
Eighth " .. ..	117	5	122	4.1 %
Total and average ..	1553	40	1593	2.5 %

The need for the secure protection afforded by good breeding places in the case of an insect like *Glossina* is fairly obvious. The adult has taken it upon itself to feed and protect the larva, but the puparia are exposed to all the innumerable parasitic and predatory destructors of Dipterous puparia in general, which are usually common throughout the world. Owing to the fostering care lavished upon the larva, very few young are produced—less than four per month per female—and it is doubtful if the average longevity exceeds four or five months. About the maximum possible rate of increase, therefore, would be 10-fold per generation, as compared with anywhere from several hundred to several thousand fold potential increase for Diptera generally. The species cannot withstand heavy mortality in its pupal stages under such conditions. Secure protection for the puparia is necessary, and the presence of the female in seeking localities for deposition of her larvae where parasites and predatory destructors rarely penetrate is extremely useful to the species. It is doubtful if any better protected places for breeding exist (at all commonly) than those actually selected most freely, in dry, clean deposits of beach sand or gravel. Except for the ants which wander over the surface, such spots are positively avoided by nearly all insects except *Glossina*, and therefore by the predatory and parasitic destructors of insects in general;\* and no parasitic or

\* It is possibly significant that the most favoured breeding places of the tsetse and of its principal host, the crocodile, are virtually identical. Much the largest deposits of puparia have been found within a few yards of crocodile nests, in the same type of soil, and under the same type of vegetation that serves partially to shade the female crocodile as she "broods" above her egg deposit.

An almost equally striking correlation between breeding places of tsetse in vegetable debris and basking spots of *Varanus*, coupled with the finding of large deposits of puparia in the sunning spots of situtunga, suggests that the specific or characteristic preferences displayed by the flies for these hosts originated in the circumstance that flies feeding on them were most likely to propagate (instead of the converse: that flies propagating on sand beaches or dry vegetable debris would therefore be most likely to feed on animals inhabiting the same localities.)

It is, indeed, most probable that the preference for certain hosts and for certain types of breeding grounds, now developed into specific characteristics, originated coincidentally, and together served to segregate *Glossina palpalis* from its congeners.



predatory entomophagid has attached itself to *Glossina palpalis*, as a "specific enemy," to follow and prey upon it in the protection of its breeding grounds.

### VII (b). Breeding Grounds in Vegetable Debris.

Quite early in these investigations a second and very distinct type of breeding ground was discovered in fine dry vegetable debris—so dry and undecomposed as to be as unattractive to insects in general as the deposits of clean-washed beach sand or gravel which are most favoured breeding places.

These deposits of vegetable debris have been found rather sparingly both under and over rocks and over coarse gravel or pebbles, which preclude soil moisture from rising to dampen them and aid the growth of fungi and other saprophagous organisms. If under rock, they must be in crevices so deep and well protected as not frequently to be wetted by storms. If over rock or pebbles, they are most frequently shaded by fern and composed of fragments of fern fronds and stems—material which does not readily decompose or attract mycetophagous or saprophagous insects or the destructors of insects.

TABLE XXX.

*Finds of Shells and Puparia of Glossina palpalis in Breeding Grounds in Vegetable Debris.*

Island.	Date.	Finds of puparia. (4)			Finds of empty shells.		
		Gross.	Per boy per hour.		Gross.	Per boy per hour.	
			Maxi-mum.	Aver-age.		Maxi-mum.	Aver-age.
Kiuwa .. (1)	Feb. 19, 1914..	3	2	0.5	317	94	57.7
Namba .. (2)	Mar. 17, 1914..	2	4	—	76	155	—
Namba .. (3)	Mar. 17, 1914..	12	6	1.6	173	50	24.7
Nsadzi .. (2)	Feb. 4, 1914..	6	12	—	86	172	—
Karambide .. (3)	Aug. 24, 1914..	34	136	—	79	316	—
Mbugwe .. (3)	Sept. 1, 1914..	8	24	—	88	358	—
Mugogoya .. (2)	Sept. 4, 1914..	24	48	—	85	170	—
Limnaiba .. (2)	Sept. 5, 1914..	3	6	—	383	576	—

(1) In very fine, dry debris under rock shelter.

(2) In basking spot of *Varanus* under fern or other low overhanging shelter.

(3) Under fern or other shelter, over pebble or cobble; in each case a basking ground of *Varanus* was near at hand.

(4) Compare maximum finds with finds from sunny and gravel breeding grounds (Table XXVI, p. 413). The average finds per boy hour in most cases would be not much greater than in the two cases given, for the breeding places are so small, as a rule, that one boy will exhaust them in 15 minutes to half an hour in cases where the breeding ground is specifically associated with a *Varanus* basking ground.

It is precisely in such spots that *Varanus* likes best to sun itself: over a rock or beach of pebbles with its body partly shaded, as by over hanging fern, and partly

exposed to the sun.\* The same animals return daily to the same places, and in moving about break up and pack down dead stems, twigs, foliage, etc., to form a finely broken, firm-surfaced mass of debris, right at the edge of low overhanging shelter. The result is excellent breeding ground for fly, definitely associated with perhaps its most favoured host, and very many puparia have frequently been found in such spots. Some of the finds made under these conditions are cited in the accompanying Table.

These breeding grounds in vegetable debris are so few and restricted in extent as compared with those in beach sand or gravel that it was for a time believed that they play no part of measurable importance in the bionomics of *Glossina*. Later on, as recounted in Sect. VII (c) following, it was concluded that they may play a part of considerable importance locally, or under rather unusual conditions—unusual, that is, for this particular region.

#### VII (c). Observations on Breeding Grounds found at a Distance from the Lake Shore.

Many small, but very few large finds of puparia have been made at points above the old beach-line of 1906. The following are the more conspicuous cases.

##### *Bugalla Island, February 1915.*

On the bay side of Lutoboka peninsula, Bugalla (Sesse) Island, is a reach of some 2,000 yards of very old beach line, about 100 to 200 yards back from the beach line of 1906. The intervening space is open grass land, the soil being very light and sandy. The forest rises abruptly behind the very old beach line, and continues unbroken to the shore on the lake side of the peninsula. The infestation along the present shore is heavy on the lake side and low on the bay side. The infestation in the forest along the old beach line is heavy, owing to the great numbers of *situtunga*.

At certain points along this old beach line in the border of the forest, where the vegetation is dense, the antelope have made sunning places for themselves by preventing new growth from springing up in openings left by falling trees. Two such points were found, near together, about 200 yards from the foreshore on the bay side and 400 yards from the shore on the lake side. The infestation was:—

	Male Density.	Female Percentage.
At shore on lake side .. ..	24.6	15.8
„ „ bay side .. ..	4.7	58.8
At sunning spots of antelopes	25.0	16.6

In the sunning spots the sandy soil was laid bare by the hoofs of the antelope, and was fine and dry. There were a few bits of it shaded by tangles of dead vines, by fallen logs, or by tufted vegetation of sorts repugnant to the animals, and puparia were found in large numbers. Exact counts were not made, but it was noted that the breeding places were as attractive and as safe as any along the shore, and that the deposits of puparia were larger than could be found at any point along the shore.

\* It is perhaps worth noting that both *crocodilic* and *Varanus* like best to bask, not in the full sun, but with a part of the body shaded. The reason was learned through use of tethered *Varanus* in feeding experiments. It was found that an hour or two of exposure to the full effects of the sun would kill the cold-blooded reptile—more quickly by far than similar exposure would kill a warm-blooded animal. *Varanus* at least (and probably *crocodile*) is more susceptible to “sun-stroke” than man.

The conclusion was reached that under such conditions, with good food in abundance, good shelter and good breeding ground, the fly would exist and thrive at any distance from the water. But it is a very rare combination at points beyond the old beach line of 1906. Usually, when the soil is light and sandy back from the water, it will not sustain vegetation sufficiently dense to serve for shelter, or for protection of any great number of antelope. Had leopards been present on this island the antelope could not have found protection from them in an environment of this sort.

It was furthermore proved by experiment that except at points where the blanket of vegetable mould that covered the sand on the old beach line had been ground under the feet of the antelope and thoroughly dried by the sun, predatory destructors of the puparia were present in exterminative numbers (see p. 443). The breeding places were made by the antelope, which thus came to provide not only food but protection to its parasites.

*Bugalla Island, December 1914 and February 1915.*

In December 1914 a remarkably heavy infestation was found on the very summit of a high hill near the centre of the southernmost peninsula on Bugalla Island. The catch of fly made at this point indicated a male density of 23.0 and female percentage of 2.5—but the record was discarded because the boys flushed a herd of situtunga and caught the “following swarm.” Probably a density of 12.0 would be nearer the facts.

The presence of inland breeding grounds was suggested by the circumstance, and by the further fact that infestation was heavier on the summit of the hill than on its slopes. They were sought for at the time, and a special trip was made to the locality in the February following to seek for them again, but without result.

This was the only inland point found on Bugalla Island, except the one above noted, where density of infestation away from the water suggested the presence of breeding places of sufficient extent to permit the fly to exist independently of breeding grounds along shore.

*Bujaju Peninsula, July 1915.*

The presence of inland breeding grounds was strongly suggested by dispersion of fly, as noted on page 385.

*Kitebo Peninsula, August 1915.*

Breeding grounds of fair quality were found on a ridge of sand representing an ancient beach line at distances up to 1,100 yards from the water. The conditions (see p. 386) suggested that the infestation at these points was mainly an extension of a riparian colony of fly inland.

*Damba Island, October 1915.*

Breeding grounds were found on a very old beach line at probably 300 yards from water, in a sunning spot of situtunga, much as noted on Bugalla Island. The infestation appeared to be an extension inland of infestation along shore. Six days were spent in exploration of Damba in search of inland colonies. Infestation inland is general, and at points quite heavy, but at no point could evidence be found indicative of any real centre of infestation with the possible exception of this one.

*Mbugwe Island, March 1915.*

The one case in which what appeared certainly to be an independent inland colony, and the only case of a colony independent of breeding grounds in sand or gravel except those on tiny islets, is described in Sect. V (*d*). This is a unique and important observation.

## VII (*d*). The "Fly Beaches."

The very notable attractiveness of shaded deposits of beach sand or gravel to the females of *Glossina palpalis*, coupled with the need of the species for protection during the pupal stages and the high degree of protection provided by the most attractive breeding places, suggested, naturally enough, that these deposits of sand or gravel are requisite to the life of the species, and that a careful survey of the region would reveal a close correlation between extent of breeding ground of this particular character and prevailing local density of the fly.

Attention was first directed toward the "fly beaches," of which there are many on island and mainland shores. They are merely open beaches of anything from fine white sand to coarse brown gravel or small pebbles mingled with more or less sand; sometimes 600 to 1,000 yards or more in length, but usually less, and backed up, first by low, bushy, semi-open shelter and secondly, by more massive shelter such as may be provided by vine-clad cliffs, but which is nearly always provided by forest.

When, as is usually the case, food is plentiful, this combination undoubtedly provides the most favourable conditions of life for tsetse that occur in this region. The combination of light backed by massive shelter is the most attractive of any to the relatively idle male flies, and the combination of light shelter and masses of beach sand or gravel affords the type of breeding ground most attractive to female flies.

In consequence the maximum degree of density (measured always by density of male flies—since activity of females is so variable a quantity) anywhere encountered in the course of these investigations, was along such a beach (Zinga Island—Table XXXI).

But though the fly beaches afford the very best condition of life for *Glossina palpalis*, other combinations are nearly as good. This is brought out by the table accompanying (Table XXXI) in which are compared:—

- I. Maximum degree of infestation (male density) encountered during fly survey of islands in January and February 1914 along fly beaches, with maximum infestation encountered elsewhere during same period.
- II. Maximum degree of infestation encountered at any time during course of investigations along fly beaches, with maximum infestation encountered at any other points.

These data indicate the absolute maximum of density encountered in the course of the investigations. The average density for the entire region was calculated on the basis of data from the first 300 observation points to be very close to 12.5.

The density at fly beaches is seen to average something over 20.0 points higher than at the most densely infested points other than fly beaches. At the same time infestation elsewhere is often very heavy.



TABLE XXXI.

*Comparison between Maximum Infestations by Glossina palpalis at Points on Fly Beaches and at other Points on Victoria Nyanza.*

		Infestation by Glossina.				
		Locality.	Date.	Catch.	Male Density	Female Percentage.
Fly Beaches.	II	Zinga Island ..	22nd Sept., 1914 ..	206	158.0	23.3 %
		Pt. No. 80, Buddu ..	3rd July, 1915 ..	288	89.5	37.9 %
	I	Wema Island ..	25th Feb., 1914 ..	203	67.0	34.0 %
		Yempaita Island ..	24th Feb., 1914 ..	377	59.6	32.2 %
		Damba Island ..	12th Feb., 1914 ..	269	55.8	6.7 %
		Nsadzi Island ..	3rd Feb., 1914 ..	391	36.4	16.1 %
Other Points.	II	Mujiuzi Colony ..	24th June, 1915 ..	358	98.0	45.3 %
		Lutoboka Bay ..	11th Sept., 1914 ..	107	60.7	15.0 %
	I	Tavu Island ..	15th Jan., 1914 ..	473	62.5	10.4 %
		Bulago Island ..	22nd Jan., 1914 ..	271	42.4	19.9 %
		Kimmi Island ..	29th Jan., 1914 ..	366	38.0	53.3 %
		Kiuwa Island ..	18th Feb., 1914 ..	245	22.2	18.4 %
	Total and averages for fly beaches			1734	77.7	25.1 %
Total and averages for other points			1820	54.1	27.1 %	

#### VII (e). Breeding Grounds on Old Beach Line.

In every case cited in Table XXXI of heavy infestation elsewhere than along fly beaches the breeding grounds were found to be in sand or gravel deposits two or three feet above the level of the lake at that time and anywhere from 10 to 100 yards back from the existing shore line. It was quickly obvious that the lake level had fallen recently, and that the character of the shore had frequently undergone radical change in consequence.

What had been a narrow sandy beach open to the lake and overhung by large trees (a fly beach, in other words) had been left high and dry, and was separated from a reed-grown, marshy foreshore by a more or less marshy and open belt, usually grass-grown and closely cropped by grazing hippo. From the water there would be no indication of any open space, or of any sand beach, nor of anything but a bed of reeds and forest to the back of it.

At other points where low flat rocks overgrown with tangled vegetation marked the existing shore line, considerable deposits of beach sand or gravel would be found a little way inland, washed up by the waves upon the shelving rocks, left behind by the receding waters, and hidden by bushy growth.

At yet other points these conditions were reversed, and what had been a rock-bound shore had become a sand or gravel beach backed by a line of rocks hidden by vegetation.

In one case what had been two small islands lying off the shore of a larger one had been united by a low isthmus, and were connected with the larger island by an almost continuous line of "merinde" or ambatch trees growing in the shallowed water.

Many other radical changes in the character of the shore line were noted, and it soon became evident that although the fly was to be found in maximum density along the open fly beaches, the great mass or body of fly bred in the deposits of sand and gravel marking the old beach line, usually hidden from sight.

Moreover in not a few cases it appeared certain that with the recession of the lake conditions of life formerly intolerable for tsetse had become favourable to it in many localities, and that in other localities the effect had been the opposite.

The question of lake level, and of fluctuations of it, was thus injected into the general subject of tsetse bionomics as one of its more important phases. Data were sought, and it was discovered that the old beach line marked the high lake level of 1906; that the existing low level was likely to be only temporary; and that at any time the waters might rise to the old level.

In consequence great changes and fluctuations in density of tsetse might be expected to occur without other warning than rise or fall of the water. Eventually, in comparing conditions on a certain reach of shore as they existed in 1915 with conditions as they had been specifically described in old reports of the officers employed on Sleeping Sickness Extended Investigations in 1906, it was found that changes in the degree of infestation had been of the most extreme character. The Mujuzi colony, for the most striking example, already mentioned several times, and last cited in Table XXXI just preceding, was non-existent in 1906.

A more detailed account of the changes wrought in specific cases is presented in Sect. XI.

In certain respects no factor in the bionomics of *Glossina palpalis* in this region is more important than this of the fluctuations in lake level, as the breeding places of the insect are affected. The rising waters uproot vegetation, clear the shore, and wash clean the beaches. Falling waters leave ideal conditions of life for tsetse where formerly they were hard or intolerable. Then the rapidly growing, tropical vegetation closes in on the breeding places, gradually shutting them off from the flies, until rising waters shall again open them to occupation.

#### VII (f). **Correlation between Extent and Character of Breeding Grounds and Degree of Infestation of small Islets by *Glossina palpalis*.**

A fly survey of small islets of less than one square mile in Victoria Nyanza was begun in December 1913 and continued through parts of January, February, August and September following. The object was to ascertain the extent to which the degree of infestation is correlated with amount and character of breeding grounds as represented by deposits of beach sand or gravel along either the old or new beach line. First and last, some 50 islets were visited. Conditions with respect to extent and character of breeding grounds were extremely diverse. On some islets no deposits of beach sand or gravel could be found—on others they were numerous and extensive. The islets may be roughly assigned to five categories, accordingly as breeding grounds of this type are "very good," "good," "poor," "very poor" or "none," and the accompanying table (Table XXXII) has been framed to include a fairly representative number from each group.

TABLE XXXII.

*Fly Survey of Small Islands in Victoria Nyanza showing Lack of Correlation between Extent of Breeding Grounds and Degree of Infestation by Glossina palpalis.*

Island.	Note.	Date.	Size (1).	Breeding Grounds.	Infestation.	
					Male Density.	Female Ratio.
Tavu .. ..	..(6)	Jan. 1914 ..	B or C	Very Good..	46.6	17.1 %
Kimmi .. ..	..(5)	Jan. 1914 ..	A	" " ..	37.2	55.3 %
Lukalu West..	..(2)	Feb. 1914 ..	B	" " ..	9.7	28.5 %
Islet S. of Dziru	..(2)	Mar. 1915 ..	D	" " ..	3.8	26.6 %
Lukalu East ..	..(2)	Feb. 1914 ..	D	" " ..	0.0	—
Kukassu .. ..	..(2)	Aug. 1914 ..	D	" " ..	0.0	—
Dwavannu .. ..	..(6)	July 1915 ..	C	Good " ..	23.0	9.8 %
Manene. ....	..(6)	Mar. 1915 ..	B	" " ..	17.7	12.4 %
Dyavadermi ..	..(2)	Mar. 1914 ..	B or C	" " ..	8.0	21.4 %
Kawari West ..	..(2)	Dec. 1913 ..	C or D	" " ..	7.8	12.5 %
Ziro .. ..	..(3)	Feb. 1914 ..	A	" " ..	5.4	23.7 %
Kirengi. ....	..(3)	Feb. 1914 ..	A	" " ..	3.8	24.7 %
Kizima .. ..	..(2)	Jan. 1914 ..	B or C	" " ..	2.5	11.0 %
Karambidi ..	..(4)	Aug. 1914 ..	B	Poor. ..	16.7	11.7 %
Namba .. ..	..(6)	Jan. 1914 ..	A	" " ..	9.4	7.9 %
Kakide .. ..	..(6)	Sept. 1914 ..	D	" " ..	8.0	—
Kibibi .. ..	..(6)	Sept. 1914 ..	B	" " ..	7.8	16.2 %
Dziru .. ..	..(6)	Sept. 1914 ..	B	" " ..	7.5	13.4 %
Kawari East ..	..(6)	Dec. 1913 ..	C or D	" " ..	4.5	4.7 %
Marida .. ..	..(3)	Feb. 1914 ..	B or C	" " ..	4.1	10.8 %
Mugogoya ..	..(4)	Sept. 1914 ..	B	Very Poor..	7.3	4.4 %
Lugazi .. ..	..(4)	Dec. 1913 ..	C or D	" " ..	6.0	15.7 %
Kisigalla ..	..(6)	Feb. 1914 ..	D	" " ..	1.7	—
Limnaiba ..	..(6)	Sept. 1914 ..	B	" " ..	1.6	—
Sanga .. ..	..(6)	Feb. 1914 ..	D	" " ..	0.2	—
Lula .. ..	..(4)	Nov. 1913 ..	D	None ..	14.0	6.0 %
Sari .. ..	..(4)	Aug. 1915 ..	C	" " ..	9.6	9.4 %
Dwanga 'Mto ..	..(3)	Feb. 1914 ..	B	" " ..	0.1	—
Semanya .. ..	..(6)	Dec. 1913 ..	C or D	" " ..	Trace*	—
Dwanga 'Mkuru	..(3)	Feb. 1914 ..	A	" " ..	Trace*	—
Dwasengwe ..	..(3)	Feb. 1914 ..	C	" " ..	0.0	—
Sentette .. ..	..(6)	Dec. 1913 ..	C or D	" " ..	0.0	—
Kadenga .. ..	..(6)	Aug. 1914 ..	C or D	" " ..	0.0	—
Kaziru .. ..	..(6)	Aug. 1914 ..	C or D	" " ..	0.0	—

\* One fly caught possibly followed canoe to island.

(1). Size of islets: A 125 to 625 acres, roughly estimated.

B 25 " 125 " " "

C 5 " 25 " " "

D 1 " 5 " " "

(2). See Sect. VIII. The factor of shelter is paramount.

(3). See Sect. IX, notes on spiders. The factor of natural enemies enters in.

(4). See Sect. VII (h), following. The factor of insularity and dispersion of fly as arbitrarily restricted on small islands enters in.

(5). See Sect. VII (i), following. The factor of food supply, coupled with that of insularity and restriction of dispersion, enters.

(6). These islands are: (a) well sheltered, (b) without undue abundance of natural enemies, (c) well provided with food, and (d) the factor of insularity appears not to count heavily or at all in its effect on infestation. They appear fairly to represent the effect of breeding grounds in sand and gravel on density of tsetse.

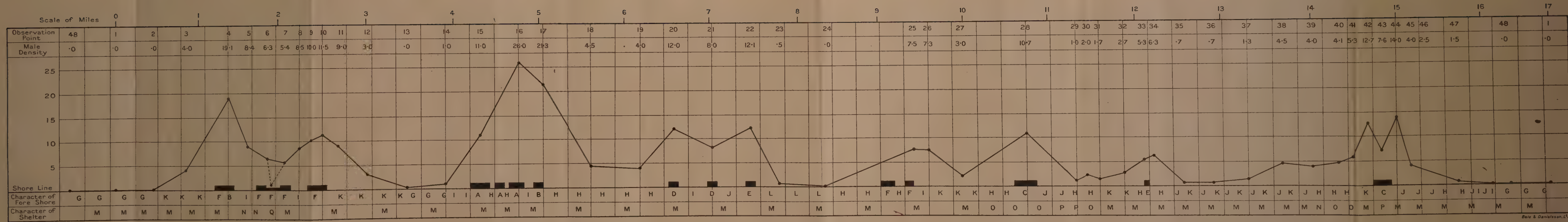


Fig. 7. Fly survey of Bugaba Island.

*For explanations see text.*





A certain correlation between extent or character of breeding grounds and degree of infestation is at once apparent, but the lack of it is rather more conspicuous than the presence of it. The scarcity of fly on the island of Lukalu West and the islet south of Dziru, and its complete absence on the very small islets of Lukalu East and Kukassu, notwithstanding the presence of good and extensive breeding places, as well as the lightness of infestation on many of the islets falling in the second group (Kizima, Kirengi, Ziro, etc.), is proof that something else that is requisite to the life of the species is either deficient or lacking altogether.

Yet more significant is the relatively heavy infestation of islands like Karambidi, Mugogoya, or most strikingly, Lula, on which breeding grounds of the sand or gravel type are poor, very poor or lacking altogether.

The food supply was adequate or much more than adequate on virtually all these islets, with the single exception of Kimi. Both crocodile and *Varanus* were common on nearly all the smallest islets, and particularly so on certain of them that were least densely or not at all infested.

Many other factors were taken into account, but none seemed adequate to explain the facts, and in August 1914 it was resolved to extend the fly survey to include long reaches of shore on the larger islands and mainland on the theory that mere insularity (i.e., excessive insularity of tiny islets of only a few acres in extent) might prove the principle source of confusion. A fairly solid foundation for this theory was subsequently found.

The first extensive reach of shore systematically surveyed was the circumference of the island of Bugaba (fig. 7), a reach of some  $16\frac{1}{2}$  miles. The results were most encouraging. A summary follows.

The characters of the foreshore of the lake, and of the soil at points along the shore is indicated in the chart by letters, as follows.

Soils of types which will serve as breeding grounds:—

- A. Brown beach gravel and sand.
- B. White sand, mixed with coarse gravel or small pebbles.
- C. Fine sandy soil, or loose sandy loam a little back from the beach line.
- D. Pebbles mixed with a little sand and gravel.
- E. Flat rock, with sand or gravel lodged in depressions.
- F. Wet sandy beaches, overgrown with grass to water's edge.

Soils and shores of types which do not serve as breeding grounds:—

- G. Bold rocky shore, sometimes precipitous.
- H. Rocky shore, neither very bold nor very flat.
- I. Flat rocky shore (without sand or gravel).
- J. Rock and marsh; or marsh with rocks protruding.
- K. Clay banks, with or without marshy foreshore.
- L. Marsh, with some floating vegetation (sudd).

Shelter immediately back from the fore-shore:—

- M. Forest, or very thick bush.
- N. Scattered bush, with open spaces.
- O. Thick bush fringe, with grass land behind.
- P. Thin bush fringe, with grass land behind.
- Q. Open grass land to water's edge.

} Sufficient shelter for fly.

} Insufficient shelter for fly.

It is to be noted that concentration of fly is apt to be greatest at a short distance from the breeding ground.

At point 43 shelter at the breeding ground is insufficient and there is a double-peaked colony, greatest concentration occurring on both sides, about equally.

At point 15, where there is a fine "fly beach" with full southern exposure, the trees grow so luxuriantly at the back of it as completely to shade it during the summer months, when the sun is in the north. At points 16 and 17 the breeding grounds are no better, but the sun strikes the beach and the flies tend to concentrate at the border line between light and shade.

Similar explanations apply at other points.

**VII (g). Correlation between Density of Infestation by *Glossina palpalis* and Location and Extent of Breeding Grounds in Beach Sand in Regions where Food and Shelter are both more than adequate.**

Bugaba was the first of the larger islands selected for exhaustive survey. It lies near the centre of the Bugalla-Bukassa group, and in its general aspects resembles those surrounding it.

Its area was roughly estimated at 4,500 acres, made up of (a) forest, rather more than one-third; (b) open grassland (formerly pasture), about one-third; (c) jungle, occupying sites of abandoned villages and plantations, rather less than one-third.

The forest fills the ravines, covers rocky and unarable slopes and ridges, and forms an almost continuous belt along the shore. The grass land lies at the back of the forest belt along the shore, and extends up the slopes to the borders of the old plantations. The villages and plantations were located on a plateau that occupied the whole central portion of the island. None were seen on the shore. There were three canoe landings, with broad foot-paths leading to the villages and plantations.

The shore line was estimated at between 16 and 17 miles. It was sheltered by forest for almost the entire distance. The southern and eastern shores, except in the large southern bay, were generally bold and rocky—at points precipitous. Elsewhere the shore was for the most part marshy, or with clay banks, but with rock at many points. In the aggregate there was between 2 and  $2\frac{1}{2}$  miles of sandy or gravelly shore which might be accounted as potential breeding ground. This was broken into numerous short reaches of from 20 to 100 yards in length, distributed irregularly along the shore line.

Infestation by *Glossina* was limited to a narrow belt along shore. At no point could flies be detected more than 400 yards inland, and at only one point could any be found more than 200 yards inland.

The longshore infestation was light. The maximum male density at any of the 48 observations points was 26.0. The average for all points was 6.7—far below the average for the lake region as a whole of approximately 12.5.

Food was plentiful. Crocodiles, *Varanus* and hippo were all common; situtunga had newly immigrated from Sesse (Bugalla) Island, and a few tracks were seen at only one point. The female percentage was very low: 7.9 for the total catch on the island.

The coincidence of infestation with the location and character of the sandy or gravelly reaches that offered potential breeding ground was gratifyingly precise. At or adjacent to every point on the shore where sandy or gravelly soil was exposed to the surface (*i.e.*, not concealed beneath grass or leaf-mould) and properly shaded, the local density of fly exceeded the average. At no point not at or adjacent

to potential breeding ground was the average exceeded. At points closely adjacent to breeding ground the shore was invariably infested, whatsoever its character—whether flat or bold, rocky or marshy or clay bank. At no point exceeding  $1\frac{1}{4}$  miles distance from breeding ground did the density exceed 1.0. At various points no flies were caught in from 2 to 5 boy-hours passed there. Absence or scarcity of fly away from breeding ground was, like presence of it at points adjacent, in no manner affected by the character of the shore, as long as it was devoid of sand or gravel deposits.

In brief, the evidence, as far as it went, was entirely confirmatory of the theory that on large islands, at least, the fly requires in addition to food and shelter the protection provided for its pupae by sand or gravel deposits and by nothing else.

Finally, it was estimated that the clearing of bush or forest from about 45 acres, or roughly 1 per cent. of the total or 4 per cent. of the arable area of the island, would suffice virtually to exterminate the fly.

The data collected during this bit of survey work are presented in fig. 6 (p. 411).

## VII (*h*). The Factor of Insularity.

The fly survey of Bugaba Island disclosed the existence of semi-detached colonies of flies, centring at or very near to the relatively few and short reaches of shore that would serve as breeding grounds.

From these colony centres flies dispersed and infested reaches of shore on either side along which it was plain that conditions of life were unfavourable to the existence of the species, except as migrants from the better protected colony centres, or centres of infestation.

It was very plain that the flies actually living in the zone of dispersion and beyond the protected precincts could not perpetuate themselves unless the females returned to the breeding grounds with their young. The chances that they may do this are best nearest the breeding grounds, and decrease as distance from the breeding grounds increases. Unless gifted with a "homing" instinct they are as likely to seek breeding grounds in the wrong as in the right direction. There is nothing whatever to indicate or suggest that they have any such extraordinary prescience.

On the contrary, the dispersion of fly from centres of infestation in protected precincts is shown by the graph of the Bugaba colonies and others, to be not incomparable to the dispersion of water welling from a spring in an arid region. At the colony centre—i.e., within the protected precincts—the fly is perpetually increasing in density, and as perpetually flowing or dispersing outward into unprotected territory, where its numbers are perpetually decreasing; much as water from a desert spring is continually dispersing outwards into the arid territory surrounding, and as continually being lost by evaporation. There is a perfect natural balance between outflow of water and loss through evaporation; an increased outflow causes more humid conditions near the source and extension of the irrigated area, until increased evaporation compensates, and *vice versa*.

It is much the same with fly. An increased amount or degree of protection at the colony centre, or anything else which is conducive to increased rate of



reproduction, leads to increased density of infestation at and near the source of it, and to wider dispersion into the unprotected territory surrounding, until increasing losses through dispersion compensate for increased rate of reproduction.

But if the dispersion of water at the desert spring were to be completely restricted to a very much smaller area than it naturally irrigates, it would tend to accumulate, and the "balance" would be destroyed. And so with fly; if dispersion of it from protected precincts is arbitrarily restricted—as actually occurs on small islets—the "balance" is destroyed, and almost anything may happen. And, indeed, almost everything likely to happen in such circumstances actually occurs on the small islets in Victoria Nyanza. The balance in the case of this species of insect is indubitably stabilised by dispersion of it from protected precincts, where conditions of life are favourable to numerical increase from generation to generation, into a surrounding unprotected "zone of dispersion," wherein conditions of life are unfavourable to numerical increase.

The mechanism of the balance rarely fails to function smoothly, except when dispersion is in some manner arbitrarily restricted. The islands afford the commonest exceptions.

The islets devoid of sand or gravel breeding places, but yet infested by *Glossina*, afford excellent proof of this conception of the "balance" with *Glossina palpalis*, and this conception provides the explanation for the occurrence of fly under these conditions of extreme insularity.

The very best example is Lula islet, which is almost, or quite, the smallest in the lake that is infested. It contains very good, but very small, breeding grounds in vegetable debris. They are so small that they would certainly not serve as colony centres if located on the shore of a large island, with no restriction upon dispersion of fly from them. But on Lula dispersion is arbitrarily restricted to a space of less than 5 acres, and to an extreme distance of, probably, less than 200 yards. The flies cannot get so far from them that they cannot readily return to them, and in whichever direction the flies seek breeding places for their young they are quickly led to this particular spot.

If Lula were a promontory on Kome Island, where conditions along shore are much the same, the infestation would be, as on Kome, extremely light or nil—the flies would naturally disperse from so restricted a bit of protected area if they could. But they are confined, as in a great breeding-cage, in a corner of which their young, if deposited there, will find protection; and they live as flies in a breeding-cage would live, not because the environment is pleasing or attractive, but because it happens to be favourable to existence and because they cannot well escape it.

The same conditions prevail on Karambidi, Mugogoya, Lugazi, Sari and Limnaiba Islands. All these, except Limnaiba, were infested to a higher degree than the extent and character of the breeding grounds seemed to warrant, until this question of insularity and restriction of dispersion from breeding grounds was considered.

On Limnaiba Island there was a very good, but very small, bit of breeding ground found, and a very much less dense infestation than experience on Lula, Mugogoya, etc., would lead one to expect. Search in this breeding ground disclosed such numbers

proportionately, of hatched shells to whole puparia (see Table XXVIII, p. 414) as to prove that a more dense infestation had recently existed; and reduction in density was explicable because of the fact that this particular spot also bore evidence of having been recently abandoned as a basking ground by *Varanus*. A similar instance was encountered on Karambidi, where in what plainly had been until very recently the basking spot of *Varanus* had also been a favoured breeding spot of tsetse, which had been very recently abandoned, as proved in this case by the most exceptional proportion of puparia in a late stage of development.

Of most particular interest in this connection are the circumstances surrounding the occurrence of an island colony of tsetse, breeding exclusively in vegetable debris on the very crest of a heavily forested hill. In this case, cited more at length in Sect. V (d), isolation was produced by the forest, which is, like open water, an obstruction to dispersion without being an insuperable obstacle to it.

It can safely be predicted that if any long reach of shore which provides good shelter and plenty of food is found with breeding places in vegetable debris at sufficiently frequent intervals, it will be found infested by fly; for then flies dispersing from one would find another. But such conditions had not been found at the close of these investigations.

### VIII. THE SHELTER REQUIRED BY *GLOSSINA PALPALIS*.

Two points in the bionomics of *Glossina palpalis* are so conspicuous as to be noted by every observer: its riparian habit, and its dependence on the shelter provided by arborescent or rankly-growing herbaceous vegetation. It is rarely found far from open water and never far from sheltering vegetation.

The effect of water upon range and density of the species appears to be indirect and coincidental, as concluded in Sect. IV; that of shelter is certainly not so. The flies absolutely require the kind of protection it affords them, and the species could not exist in the absence of it.

It was not expected that these studies would lead to any new discoveries concerning the specific types of sheltering vegetation that provide necessary protection, but it was taken too much for granted that where the flies were found in largest numbers the shelter would be, at least, adequate. This proved not so; and it was discovered that the shelter most attractive to the active flies, or that serves best to shade breeding grounds and as protection for the puparia, is frequently inadequate as protection for the inactive flies. Two kinds of shelter are requisite, (a) light, such as serves at breeding grounds and for the active flies; and (b) massive, or forest-like, which is required by the inactive flies.

In no other manner was it possible to explain the distribution of fly on the islands, as disclosed by the island survey. The idea was made a working hypothesis, and subsequent survey work sufficiently confirmed it, as recounted in the following pages.

#### VIII (a). Correlation between Character of Shelter and Infestation of small Islands by Fly.

Reference to Table XXXII will show that though on certain small islands, notably Lukalu East and Kukassu, infestation was nil despite the presence of "very good"

breeding grounds. Food, also, was especially common on these islets, and the only reason which could be assigned for absence of fly was the total lack of what has been called "massive shelter" of the sort provided by large trees in masses, or very heavy masses of shrubbery; in short, by either true forest, or by a type of vegetation approximating true forest.

If this were the true explanation it would serve also to account for lightness of infestation on various other islands—notably Lukalu West and Kizima, which possess relatively to such islands as Tavu, Kimmi, and nearly all of those of larger size, but little massive shelter.

TABLE XXXIII.

*Showing Correlation between Character of Shelter and Infestation of Small Islands by Glossina palpalis.*

Island.	Character of breeding ground.	Character of Shelter.		Infestation.	
		Light.	Massive.	Male density.	Female percentage.
Tavu .. ..	Very good ..	Good ..	Very good ..	46.6	17.1
Kimmi .. ..	Very good ..	Very good ..	Very good ..	24.3	57.5
Manene .. ..	Good ..	Good ..	Very good ..	17.7	12.4
Dwavannu .. ..	Good ..	Good ..	Good ..	23.0	9.8
Ziro .. ..	Good ..	Good ..	Good ..	5.4	23.7
Kerenge .. ..	Good ..	Good ..	Good ..	3.8	24.7
Lukalu West .. ..	Very good ..	Very good ..	Poor ..	9.7	28.5
Dyavadermi .. ..	Good ..	Good ..	Poor ..	8.0	21.4
Kawari West .. ..	Good ..	Good ..	Poor ..	7.8	12.5
Kizima .. ..	Good ..	Good ..	Poor ..	2.5	11.0
Islet S. of Dziru .. ..	Very good ..	Very good ..	Very poor ..	3.8	26.6
Lukalu East .. ..	Very good ..	Very good ..	None ..	Nil.	—
Kukassu .. ..	Very good ..	Very good ..	None ..	Nil.	—

Opposed to the theory that massive shelter is necessary was the fact that the active flies showed a strong preference for such light shelter as is provided by low massed shrubbery with open spaces between thickets or clumps of it, masses or clumps of rank-growing herbs, vine-covered bushes, or stumps, etc. This is the kind of shelter that provides shade for the most attractive breeding places, and it is indubitably most attractive to the active flies of both sexes.

Opposed to the theory also was the fact that such long, narrow sand-pits as Crocodile Point on Bulago Island, which are devoid of massive shelter and semi-detached from the main body of the island (or mainland), are apt to be densely infested by fly. There is more and better massive shelter, and much better breeding grounds, on the island of Kizima, for example, than on Crocodile Point, Bulago; yet the infestation of Kizima, in January 1914, was only 2.5 as compared with 22.7 at Crocodile Point.

This last objection is met, however, by the facts disclosed in the catching experiment on Crocodile Point cited in Sect. III (a), which proved conclusively enough



that the fly population was not permanently resident, but was continually moving, and that virtually all flies infesting it at a given time were likely to move away from it in the course of a day or two, to be replaced by others. On Kizima the flies have not this privilege. They must remain on the islet and put up with whatever shelter it affords, or leave it permanently. If Kizima were a peninsula of Bulago, like Crocodile Point, its light shelter and breeding grounds, and the great quantity of food it provides, would certainly attract to it even more flies than infest Crocodile Point; but it must be concluded that its heavy infestations under such hypothetical conditions, like the heavy infestation actually existing on Crocodile Point, would be, as the other certainly is, due to the existence of good massive shelter within range or reach of the flies infesting it.

These same facts concerning the movements of flies along shore, or along other favourite courses, answer also the first objections made above. The active flies are active with some positive object; the females are seeking either food or breeding places; the males are seeking either food or association with the females. Light shelter provides the best shade for breeding places, and food (*Varanus* and crocodile especially) is most frequently encountered associated with it; therefore it is sought by the females and equally by the males during their hours of activity. At other times (during the night, storms and dull weather generally), both sexes remain in seclusion, and it is then that massive shelter is presumptively necessary for their protection.

A large number of data collected during the course of the survey of small islands sustained this as the true explanation for lightness or absence of infestation on a fair number of them. The data are of a sort not easily presented, and Table XXXIII is suggestive without being conclusive. Reliance in drawing conclusions was principally placed in such comparative studies as between infestations at points such as are illustrated in the sketches accompanying (fig. 8).

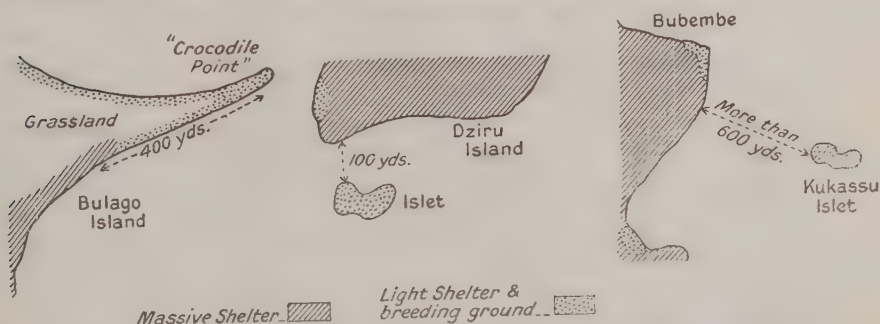


Fig. 8. Illustrating the correlation between character of shelter and infestation of small islands by *Glossina*.

In each of the three cases we have an area of light shelter with good to very good breeding grounds located in certain relations to massive shelter. These three localities are roughly equal in gross area and attractiveness to fly; the two islets being rather superior to the peninsula than otherwise.



The first, at Crocodile Point, lies from 0 to 400 yards from massive shelter on Bulago Island. Infestation was:—

Crocodile Point (Jan. 1914): male density 22.7; female percentage 42.9.

Near massive shelter on south shore of island: male density 20.4; female percentage 40.6.

The second area of light shelter and breeding ground was on an islet south of Dziru, and separated from massive shelter by an open channel of about 100 yards in width. This served as a serious obstruction in free movement of fly. Infestation in March 1915 was:—

Islet: male density 3.8; female percentage 26.6. Island: male density 5.0; female percentage 44.4.

In September 1914 infestation at these same points had been:—

Islet: male density 1.5; female percentage 0. Island: male density 6.5; female percentage 13.3.

The third area is the islet of Kukassu, which is more than 600 yards off the shore of Bubambe Island, which is the nearest massive shelter. This width of the channel is a complete obstruction to movement of fly. In consequence, infestation, in August 1914, was found to be:—

Kukassu Islet: *nil*.

Bubambe Island (at point opposite): male density 13.7; female percentage 7.8.

These and other data of a similar character provided a weight of evidence that was in the end conclusive; lightly sheltered areas may provide the best and most attractive hunting, breeding and assembling grounds for *Glossina palpalis*, but unless they lie within easy range or reach of the flies from massive shelter they will not be infested. If there is no obstacle to free movement of flies between such areas and massively sheltered areas, they are apt to be more densely infested than the other. But as distance or obstacles to free movement increase, infestation diminishes, until finally beyond certain limits they cease to be infested.

#### VIII (b). Correlation between Type of Shelter and Density of Fly as disclosed by Survey of large Islands and Mainland.

In the beginning it was expected that the survey of small islands and comparisons between them with respect to environmental conditions and density of infestation would be productive of the most valuable data. But it was discovered that insularity, as it affected the normal dispersion of fly (p. 425), was so confusing a factor that the data secured through the survey of long reaches of shore on the mainland and large islands were much more satisfactory.

Especially is this true where the survey reveals, as on Bugaba Island (fig. 7, p. 423), in the Bwendi District (fig. 6, p. 411), at Dumo Point and Mujuzi Creek (fig. 5, p. 388), etc., the existence of well defined, isolated or semi-isolated colonies of fly, each with a sharply defined nucleus, from which flies are continually dispersing to infest a zone surrounding.

The most interesting of all the colonies encountered in the fly survey was certainly that at Mujuzi Creek, of which so much has been written, and which centres at a point where food is provided in a region that is deficient in food. The second in

interest is probably that on Lutoboka Bay, illustrated by figure 9, which centres at a point where shelter is adequate in a region that is devoid of good shelter. Study of it in September 1914, and at various subsequent visits, provided evidence deemed absolutely conclusive concerning the need of massive shelter within easy range or reach of *Glossina palpalis*. The colony (fig. 9) is seen to centre at the point where the heavy shelter of a forest belt ceases, and light shelter of a type especially attractive to active flies begins. There are breeding grounds at intervals all the way from point 10 to point 17, but density falls away almost as abruptly in this direction as in the opposite, where light shelter is lacking, and where a positively repulsive belt of sudd (papyrus and saw-grass) fringes the shore.

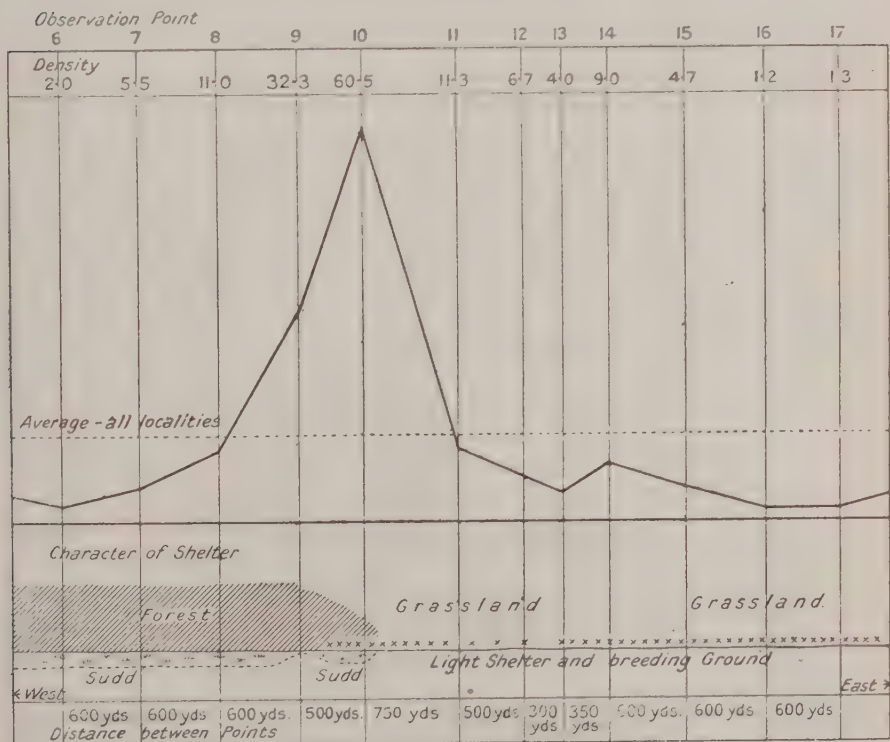


Fig. 9. Diagram showing effect of shelter on range and density of *G. palpalis* in Lutoboka Bay.

Another interesting colony is that shown at points 40 to 46 in figure 7 (p. 423), and also in another connection in figure 3 (p. 371). In this case a short reach of light shelter is flanked on either side by massive shelter, and a double-peaked colony results: i.e., it is either two colonies fused broadly together, or one colony with two nuclei.

An exceedingly interesting reach of shore is one of about five miles along the southern margin of Buganga District in Buddu. Its western extremity is plunged into a great sudd field. Beginning at a point where the sudd gives way and permits landing, there is a reach of 200 yards (estimated) where an almost continuous line of thick shrubbery and other low vegetation grows along a sand embankment which represents the beach line of 1906. Inside this is a short grass, sandy plain, with large herds of water-buck and some zebra. Just outside it are many semi-open spaces of a sort very attractive to fly, with most excellently shaded breeding grounds. Crocodile and hippo are unusually numerous. (Points 1 to 6, inclusive, Table XXXIV.) For the next 2,700 yards the shore becomes very marshy and no attractive shelter could be detected from the water, until at point 8 a narrow ridge of sand outside a belt of light shelter again appeared, continuing to point 9, where for the first time massive shelter was encountered. Beyond this point the shore was diverse and fairly heavily infested.

TABLE XXXIV.

*Catches of Fly along Southern Shore of Buganga District, Buddu, showing Effect of Massive Shelter on Density.*

Observation point.	Distance beyond preceeding point.	Shelter along shore.		Infestation.		
		Massive.	Light.	Catch.	Male density.	Female percentage.
1	.. —	None	Very good	0	—	—
2	.. 900 yds.	None	Very good	4	0·7	0 0
3	.. 600 „	None	Very good	1	0·0	100·0
4	.. 800 „	Very poor	Very good	9	1·8	0·0
5	.. 900 „	None	Very good	0	0·0	—
6	.. 1,000 „	None	Very good	1	0·2	0·0
7	.. 1,500 „	Very poor	Good	8	1·7	37·0
8	.. 1,200 „	None	Good	22	2·3*	68·0
9	.. 800 „	Good	Good	90	17·0	43·0

\* Heavier density represents dispersion from point 9, which was a colony centre.

The point of exceptional interest, however, is No. 4, which was selected as that one where the fringe of light shelter seemed to be the heaviest along this first section of lightly sheltered shore. To all appearances such shelter as was present had sprung up since the high lake-level of 1906, for it was principally growing on an embankment that was the beach line at that time. Moreover, it appeared to be growing heavier and denser in 1915; promising to become, in time, a forest fringe separating the short grass plain from the lake. It had already become so heavy or massive that it would have caused no surprise to have found the shore infested to an average degree. The extreme lightness of the infestation was certainly due to lack of more massive shelter, however, and could not be attributed to any other cause.

But shelter was growing—or seemed to be growing—more massive with each year that passed. It seemed altogether probable that in another year it would become sufficient to protect *Glossina* adequately, and at point 4 the embryo of a future colony appeared actually to exist. Despite the small size of it, it seemed to represent a real independent colony, that would grow, as its protection grew, to become in a few years just such a colony as occurs in the Bukakata district. The conditions of life were almost identically the same in the two localities, except that along the reach of shore in the Bukakata district the vegetation was a few degrees more massive, and afforded that much better protection. The difference cannot be described, and would be difficult to measure, but it represents the line of distinction between shelter that is adequate and shelter that is not adequate to protect the fly.

The main point is that light, low shelter, of the type that is most attractive to the active flies, and that is most certainly to be associated in the mind of the casual observer with the fly, is entirely insufficient to afford the species the protection it requires. Massive or forest-like shelter must be had. It may not exist within several thousand yards of a point where fly occurs, seemingly well satisfied with its environment, but in such cases it will certainly be possible to trace the source of infestation to centres located close to the forest growth.

It may be added that a cliff overgrown with vines and shrubbery has been observed to serve as massive shelter.

Reference back to figure 3 (p. 371) will show again the effect of absence of massive shelter on density.

At points 40, 41, 45 and 46 massive shelter was good but light shelter absent or lacking.

At point 43 light shelter was good but massive shelter lacking.

At points 42 and 44 the light and massive shelter were in juxtaposition, and here were the centres of greatest concentration of fly.

#### VIII (c). Occurrence of *Glossina palpalis* behind Papyrus or Sudd.

At many points on islands and mainland narrow belts of floating vegetation (usually papyrus) have formed along sheltered reaches of shore which appear to have been open in 1906—or if not then, very recently. The old beach line of 1906, not infrequently with good breeding grounds, lies behind the sudd belt, which is traversed by passage ways kept open by hippo and crocodile. The crocodiles land and sometimes breed in these places, which retain much of their original character. Fly is commonly found, and in considerable density, in such situations. It would be strange if it were not.

Much of the shore of the lake, especially in the large sheltered bays and channels in the north-western limb of it, is permanently bound by much older fields and banks of sudd. Inside of these the shore line has changed from its original character to resemble the border of a marsh. Sand and gravel beaches, where they existed, have usually been buried beneath humus or are densely overgrown with vegetation.

In July and August 1915 special effort was made to discover if fly were bred under these conditions. The following surveys were made.



*Bujaju Peninsula, 30th July and 2nd August 1915.*

A great bay (not shown on Whitehouse's Chart) lying west of Bujaju Peninsula is entirely sudd-bound, but with a central channel open. At several points hippo trails traverse the sudd belt. At one point, where the soil is sandy, crocodiles come ashore to breed. The width of the sudd belt is unknown. The distance from the crocodile breeding place to any break in the sudd which would make a canoe landing practicable is not less than 5 miles. The distance across the arm of the peninsula to any point on the eastern shore, or any point where fly has been found inland, is not less than three miles.

What appeared to be a small colony of fly was found. The catch (in 16 boy-hours) was males 5, females 1, giving a density of 13 and female percentage of 16.6.

*Bunjako Island, 10th August 1915.*

The western shore, separated by sudd-bound channels from the mainland was surveyed for about 5 miles. Situtunga were fairly common at the point, bush-pig common, a few bush-buck, and a very small herd of buffalo; no landing places of amphibious animals, and no trace of fly.

*Kitebo Peninsula, 13th August 1915.*

Surveyed eastern shore of peninsula, being the western shore of sudd-bound channel separating mainland from Bunjako Island, for distance of  $3\frac{1}{2}$  miles north from last break in sudd belt. At the point sandy soil and ancient beach line, semi-open, offered fair breeding places and good shelter. Game not common, no amphibious animals, and no trace of fly beyond the first few hundred yards.

*Zinga Island, 20th-22nd August, 1915.*

Surveyed north-western peninsula (not shown on Whitehouse's Chart) on northern and western shores. It is anciently sudd-bound. Many situtunga were seen and one animal that appeared to be bush-buck; excreta of leopard at one point; no amphibious animals.

Dense infestation at south-western point of the peninsula (where there is no sudd) spread inland for at least 1,000 yards, owing to situtunga. No trace of fly at much more than 1,000 yards from open shore on this portion of island. No sand or gravel found at the back of the old sudd-fields.

*Binga Island, 23rd August 1915.*

Binga is entirely sudd-bound. The narrowest portion of sudd-belt is about 100 yards in width; except at this one point it is much wider. Bush-buck, bush-pig and buffalo all common; situtunga not common; hippo land frequently where sudd-belt is narrowest.

Fly was found near hippo landings; in 13 boy-hours 11 were caught, making density of .5, and the female percentage was 45.4. There is a chance that these flies followed the outer border of the sudd-field from the point where it breaks on the stem of Bunjako Island, 3 to 4 miles distant, and that they turned up the hippo trails to Binga. There seemed less probability of this being an independent colony—i.e., a self-perpetuating colony—than in the case of fly caught on the western shore of Bujaju.

Conditions at the back of ancient, permanently anchored fields and belts of sudd are somewhat more likely to be favourable to the existence of *Glossina palpalis* than conditions at inland points generally, because there is apt to be sandy soil sufficiently well watered to sustain sheltering vegetation. But it is improbable that the necessary combination of food, shelter and breeding places would exist at all commonly unless the sudd-belt is so narrow as to permit landing of amphibious animals.

It is a safe enough presumption that a sudd-belt not traversed by hippo or crocodile trails is free of fly on its landward side, but narrow belts crossed by hippo or crocodile trails should not be regarded as sufficient protection against fly.

#### IX. THE INIMICAL FACTORS IN THE BIONOMICS OF *GLOSSINA PALPALIS*.

The natural enemies and other inimical factors in the bionomics of *Glossina* are numerous and diverse. For this very reason they are peculiarly difficult to identify and study. It is much more simple and practical to study the more specific and easily defined protective factors than the more numerous, less specific and less easily defined destructive and otherwise inimical factors against which they afford protection.

For example, shade at breeding grounds is protective against the destructive effects of sun, and the clean-washed deposits of sand or gravel which are most favoured as breeding places are protection against many different species of parasitic and predatory destructors of insects, that are generally distributed and common in most other types of soil than these. If shade at the breeding grounds is destroyed, the puparia in these are quickly killed by the sun; and if there are no other breeding grounds left to the fly in that district, it will soon be exterminated, either through lack of protection or through the operation of destructive factors, according to the point of view. But though shade is specifically protective against a specific destructive factor, it is not that factor which operates exterminatively when protection against it is destroyed; it is the parasitic and predatory enemies which become exterminative, because the flies will most certainly not deposit their young in unshaded situations to be destroyed by sun. They will seek shaded places, wherein ants, perhaps, or ground beetles or beetle larvae, or yet other predatory creatures will be the destructive agents, according to the particular spot that they select.

It is impossible in such cases to specify the destructive agents actually responsible for extermination of the species. The breeding grounds are a protection against not one or two but against a whole coalition of enemies, any one of which may be exterminative if the flies were to deposit all their larvae in situations exposed to that particular one, and all of which are impotent to destroy if the one specific form of protection is provided and utilised by the flies.

Moreover it is difficult to see how knowledge of the inimical factors can be made of practical application. If we have a knowledge of the protective factors, they can be utilised, for by depriving the insect of its protection very practical utilisation can be made of its destructors. But knowledge of the destructors is valueless unless it includes knowledge of the protection which serves the species against them. It

is necessary to deprive the fly of protection in any event (before its destructors can be utilised) and knowledge of protective factors in its bionomics must be acquired sooner or later.

The deprivative factors in the bionomics of *Glossina* appear, on the whole, to be more efficacious in restricting its range and density than the destructive. They include all the destructive and otherwise inimical factors in the bionomics of its host species, and, in addition, whatever else may operate to render its food supply less easily accessible or available. But the many deprivative factors are as difficult to identify and define as the destructive, and it is simpler and more practical to study the more specific food factors than to attempt to identify and study the less specific destructors or deprivators of food.

In short, except as a matter of curiosity or technical interest, or as it may assist, sometimes, in confirming conclusions or supplementing evidence bearing on doubtful points, it appears neither necessary nor desirable to devote time and energy to investigation into the identity and nature of the factors inimical to *Glossina palpalis*. If the object for investigation into its bionomics was to cultivate it, as a beneficial species, there would be the same object for studying its enemies that there is for studying it as an enemy of domestic animals or human populations, namely, to find means of protection where protection is lacking. But inasmuch as the object is to destroy and not to cultivate it, and because, obviously, it is protected against all its destructors and other inimical factors in the districts which it infests, it appears much the more logical as well as the simpler and easier course to limit all specialised or intensive studies to the factors responsible for its presence rather than to attempt inclusion of factors manifestly unable to prevent its presence in injurious density. On the face of it, destructive factors are locally impotent and inoperative, and the reason for this must be found before they can be made operative and useful; if it can be learned how the pest is protected against them it may be possible to deprive it of such protection and thus to make practical utilisation of them, but not otherwise.

On these accounts relatively little attention was devoted to the inimical factors in the bionomics of *Glossina palpalis*. A few experiments were made, and these, together with a summary of miscellaneous observations covering a very wide diversity of enemy species, are cited in the following pages.

#### IX (a). The Hosts of the Fly as Destructive Factors in its Bionomics.

The bite of the tsetse is frequently painful enough to invite vigorous retaliation on the part of any but the thicker skinned and least sensitive host animals, and an active, sensitive host would thus become a destructive enemy of the first importance if the flies were forced to feed upon it, or were foolish enough to press their attack upon it regardless of consequences.\* It is not improbable, however, that the tsetse is

\*The very active and very sensitive host is as much an enemy of the flies as any parasite or predatory destructor known. There are many parasites and predators which would destroy the flies if they did not employ self-protective tactics against them; there are several species of host animals which would do the same if the flies were devoid of self-protective instincts. The flies are actually exterminated by neither because of specialised instincts of self-preservation.



quicker to detect danger from this source and more successful in protecting itself against it than any other biting fly. Certainly it is quicker to "dodge" a blow and more difficult to capture bare-handed than any other biting fly known to me, and it is also the quickest to desist from attack upon a dangerously alert and sensitive host.

The most dangerous of its potential hosts are probably monkeys, and it is exceedingly doubtful if it could exist if forced to feed off them alone. Monkeys are not only alert, sensitive and very quick of movement, but are expert catchers of insects.

Sheep and goats are almost equally intolerant, but less dangerous, by far. They strive to evade being bitten rather than to destroy the aggressor.

It was noted of the young bull used in the experiment cited on p. 402 that he strove to destroy his tormentors, striking vigorously with head or foot, in quite sharp contrast to the behaviour of the sheep used in the same experiment.

Man, however, is probably the most potentially destructive host next to monkey. The ordinarily sensitive individual would destroy nearly every fly which he detected in the act of feeding (occasionally the bite is absolutely painless and the fly engorges before being detected), were it not for the extreme quickness of the insect. The chances of a fly's being able to engorge undetected are not at all good, and if deprived of all other than human hosts many would become very hungry before they succeeded in engorging. The very hungry flies take desperate chances, and press their attack so viciously and persistently that they are frequently destroyed. This was characteristic of the flies in the Mujuzi Creek colony, where they pressed their attack so persistently that so many were destroyed as to make it difficult to imagine that the species could exist as a parasite of man alone.\*

#### IX (b). Predatory Destruction of Adult Flies.

##### (1). *Spiders*.

One of the conspicuous biotic phenomena along the shores of Victoria Nyanza is the incredible number of spiders that occur locally at points along the mainland shore, or on small islets. There are numerous species, the most conspicuous of which is a gigantic web-spinner identified (by Mr. C. C. Cowdrey, Government Entomologist of Uganda) as *Nephile pilipes*. The full grown individuals of this species habitually stretch their webs from one tree or bush to another across openings in bush or forest, or between the trees and bushes growing not too distantly separated along the lake shore.

There are several other large species which appear like the *Nephile* to be quite independent, and many small species which are not independent, but which live—in proportionately incredible numbers—as guests orinquillines of the larger species—sometimes by robbing their webs of the small insects entangled in them, and sometimes by spinning their finer webs in the coarse meshes of the webs spun by the larger species.

\* So alert, quick and sensitive a host as man must be approached by insect parasites with considerable circumspection; the successful insect parasites of man appear either to approach him while asleep, as in the case of the bed-bug, the floor maggot, most mosquitoes, etc., or to be extraordinarily insidious, like the chigger, or to be exceptionally resistant to retaliatory activities like fleas, and some others.



At times the great webs of the *Nephele* are so numerous that in passing through semi-open spaces along shore one must strike them down at every step, and literally hundreds of the gigantic spiders can be seen through openings between the trees, each suspended in the centre of its web and silhouetted against the sky; and not the least remarkable feature of the phenomenon is that one small islet may be thus festooned, and another, a few hundreds or thousands of yards away, may be entirely free. Several of the islets and small islands lying off the shores of Kome (fig. 1) have been found densely infested, but Kome itself has always been entirely free.

These webs are frequently stretched squarely across the courses which would naturally be followed by streams of food-hunting flies, and are inevitably a source of considerable danger. The flies are well aware of it, and remarkably successful in avoiding capture; still many of them become entangled. Of these a fair proportion escape by the strength and vigour of their actions, but a proportion are destroyed.

On the island of Wema, in February 1914, a light infestation by spider and dense infestation by fly afforded opportunity for study, and counts were made of insects as large as or larger than tsetse that were found entangled in the webs, with results as shown in Table XXXV. It should be noted that of the seven tsetse recorded five were found entangled on approaching the webs, and two became entangled while the webs were under examination.

TABLE XXXV.

*Insects found entangled in Webs of Nephele pilipes.*

Insects.	In webs along fly beach, 27th Feb.	In webs in old plantations, 1st March.	Total.
Odonata . . . . .	1	2	3
Ephemeroidea . . . . .	4	1	5
Orthoptera (Acridiidae) . . . . .	4	9	13
Homoptera (Fulgoridae) . . . . .	0	14	14
Hemiptera . . . . .	4	4	8
Lepidoptera . . . . .	9	14	23
Coleoptera . . . . .	3	6	14
Hymenoptera . . . . .	8	11	14
Miscellaneous Diptera . . . . .	5	2	7
Glossina . . . . .	5	2	7
Total . . . . .	43	65	108
Percentage Glossina . . . . .	11.6	3.1 %	6.5 %

The unexpectedly high percentage of *Glossina* amongst the insects of equal or larger size captured by the *Nephele* rendered it extremely probable that where infestation by spider is excessively heavy it must have some effect in reducing local density of tsetse, and it is believed that its effect is fairly measured in the

accompanying table (Table XXXVI). The two islands of Ziro and Kerenge were very densely infested by spiders, but otherwise they appeared to be in all respects as favourable to tsetse as the other islands named in the table. Both were accounted "better than Namba" and "as good as Bulago" in the final summing up of impressions gained during the several days spent in the survey of each.

TABLE XXXVI.  
*Effect of Spider on Density of Glossina palpalis.*

Island.	Date.	Character of Environment.				Infestation.	
		Shelter.	Breeding grounds.	Food.	Spider.	Male density.	Female ratio.
Bulago	Jan. 1914	Good	Good	Good	None	27.5	29.0 %
Nsadzi	" "	"	"	"	"	18.4	24.6 %
Kitebo	Dec. 1913	"	"	"	"	14.5	33.7 %
Namba	Jan. 1914	Very good	Poor	Very good	"	9.4	7.9 %
Ziro	Feb. 1914	Good	Good	Good	Exceeding-ly many	5.4	23.7 %
Kerenge	" "	"	"	"	"	3.8	24.7 %
Average infestation of islands with no spider						17.2	23.3 %
" " " " " many spiders						4.6	24.2 %
Reduced infestation attributed to spider						12.6	73.3 %

Numerous other islands were found to be heavily or excessively infested by spiders, but in the case of no others was comparison with spider-free islands so generally fair.

It is possible that if conditions of life otherwise were less favourable than on Ziro and Kerenge, the spiders in comparable density might prove an exterminative destructor. The islands of Dwanga Mkuru, Dwanga Mto and Dwasengwe noted in Table XXXII (p. 422) as very lightly or not at all infested may possibly owe freedom from fly to infestations by spiders, which was fairly heavy in each case, as well as to absence of breeding grounds.

## (2). *Dragonflies.*

A dragonfly of a rather small and undetermined species occurs commonly, but irregularly distributed, throughout the islands and riparian belt. There are other species, but this one is conspicuous for its numbers and for a well marked habit of following moving animals and man and feeding off the flies which are attracted to them. Large numbers—in exceptional cases perhaps as many as 40 or 50—of these dragonflies may follow a man along the open shore, and they have been observed to capture tsetse many times.

The species varies greatly in local density from one island or district to another. It was observed most abundantly along the western shore of Bukone Island in September 1914. A fairly complete survey of the island was made and the infestation indicated (male density 8.6; female ratio 23.4 per cent.) was considerably

lighter than conditions, apart from the very exceptional number of dragonflies, would have led one to expect. It seemed quite probable that the destructor was responsible for a considerably less heavy infestation than would otherwise have occurred.

There is this difference between spider and dragonfly—that sheltering vegetation is of little or no protective value against spiders, but of much protective value against dragonflies. They will not follow a moving animal into cover, and the flies are not likely to be captured unless they hunt in the open.

Apart from spiders and dragonflies no destructive enemies of tsetse have been observed that appeared to be specifically responsible for appreciable reduction in density of *Glossina palpalis*.

(3). *Bembex*.

A wasp of the genus *Bembex* works somewhat like the dragonfly in following moving animals and picking off flies attracted to them. Its habits have been described by Dr. Carpenter. Though very variable in density it is nowhere excessively common, and at most points was not observed to occur at all. It would stand third in importance of the destructors of adult flies observed at work, but at no point did it appear to produce an appreciable effect on density of fly.

(4). *Miscellaneous Destructors*.

Small lizards are among the most numerous of entomophagous creatures which hunt in the haunts of tsetse, and it has seemed probable that they destroy many flies. They are nearly everywhere common, and vary relatively little in local density.

A fair number of other entomophagids have been observed working in the haunts of tsetse, but none among them has appeared to be sufficiently numerous to be of any consequence as an enemy.

It is to be noted, however, that it is virtually impossible to study the actual or potential destructors of the inactive flies. It is almost impossible to discover the inactive flies without putting them to flight, and nothing is known of the specific dangers that beset them.

IX (c). **Parasitic and Predatory Destruction of the Larvae and Puparia.**

(1). *Ants*.

Almost the only insects common at breeding grounds in clean-washed deposits of beach sand and gravel are the ants which run about over the surface. These would destroy the weak larvae of tsetse if the latter did not bury themselves quickly below the surface. The prescience of the female flies guides them to spots where their young are not unduly exposed to this danger.

There are numerous species of ants which will destroy the puparia if encountered, but none of these are known or suspected to burrow beneath the surface of the soil in breeding grounds in search of buried puparia. The "red driver" and some other of the larger ants will carry the puparia away bodily.

In woodland, or where there is a thick blanket of decaying leaves on the surface of the soil, there are species of ants which work under the loosely packed material and which will destroy any Dipterous puparia encountered in it. If flies ever selected

such localities as breeding places it is probable that their young would not penetrate deeply enough to escape these wandering ants, but the flies appear never to deposit their young in such places.

It is with ants as with so many other potential destructors, including monkeys and spiders. If flies fed or attempted to feed on monkeys they would be destroyed; if they flew headlong into the webs of spiders their species would probably be exterminated on the spider islands; if they failed to display characteristic prescience in the selection of breeding places, their young would be destroyed by ants, parasites, etc.; but in each case their instincts save them from destruction.

(2). *Hymenopterous Parasites.*

The parasitism of puparia of *Glossina palpalis* in good breeding grounds by Hymenoptera was found to be absolutely negligible. The only instance encountered was on Wema Island, where in a catch of 203 puparia, 3 were found attacked by a small gregarious Chalcidid. A percentage of parasitism at this point of 1.5 was thus indicated. At other points near at hand enough more unbroken puparia were collected and examined to make a total of 1,775, and not another parasitic specimen was found. From other points, first and last, more than 3,000 living puparia were collected and examined, making some 5,000 in all, and no other case of parasitism was encountered.

Occasionally empty shells are found with small round holes such as are left by Hymenopterous parasites in emerging, but except at the one point noted above, examination of such shells has never disclosed the characteristic (and unmistakable) exuviae of such parasites. The selected breeding grounds of the species are practically absolute protection against this class of destructors.

The parasite discovered on Wema bred with the greatest freedom on puparia of *Glossina* in confinement. About one month was required for the generation. It could be an enemy if it would, but its instincts lead it elsewhere than in the breeding places of *Glossina* in search of prey.

(3). *Miscellaneous Predatory Destructors.*

Ground beetles and their larvae of several species, Carabids and Elaterids, are known to be destructive to puparia, and believed to be very destructive to them except in the dry deposits of sand, gravel and fine vegetable debris normally chosen by the female flies. These, or other destructors unknown, frequently destroy appreciable proportions of puparia, varying in different localities. It was thought probable that counts of "eaten" and "hatched" shells found at breeding grounds in sand and gravel would show a much lower proportion of "eaten" than at breeding grounds in vegetable debris. The actual counts, however, showed no great difference and indicated that the degree of protection provided by vegetable debris is almost equal to that provided by beach sand and gravel (Table XXXVII). There is a much greater difference between good and poor breeding places in sand and gravel or in vegetable debris than between sand or gravel as compared with vegetable debris.

The two instances on Mbugwe and Nsadzi Islands where destruction by predators amounted to 27.2 per cent. and 31.2 per cent., respectively, are worthy of special mention. In each case the prescience of the female was deceived by superficial conditions. Both cases were in basking spots of *Varanus*. That on Nsadzi Island



was in the very centre of a great tuft of grass that had been killed by overhanging (encroaching) shrubbery. The fine dead leaves of grass had been pressed down by the body of the animal to present a firm smooth surface, quite dry. But underneath, the grass leaves were moist and decaying, and the larvae of tsetse, penetrating the surface and forming puparia in the damp interior were largely destroyed. The case on Mbugwe Island was very different. Here there was a layer of vegetable debris under fern and over pebbles that had been packed so firmly by the body of the *Varanus* that the larvae could only penetrate with difficulty. Many were forced to form puparia only half concealed and of these all were destroyed.

TABLE XXXVII.

*Showing Relative Degree of Protection to Puparia of Glossina palpalis provided by Breeding Grounds in Beach Sands and Gravels and in Vegetable Debris.*

Locality and Date.	Character of breeding ground.	Finds of puparia shells.			Proportion destroyed by predators.
		Hatched.	Eaten.	Total.	
Damba .. Feb. 1914	Coarse sand .. ..	1074	89	1163	7.6 %
Kerenge .. Feb. 1914	Sand and gravel ..	152	3	155	2.0 %
Wema .. Feb. 1914	Brown sands and gravels .. ..	2974	70	3044	2.3 %
Bugalla .. Sept. 1914	White sand .. ..	81	3	84	3.5 %
Zinga .. Sept. 1914	" " .. ..	457	21	478	4.4 %
Damba .. Feb. 1914	" " .. ..	3939	554	4493	12.3 %
Nsadzi .. Feb. 1914	Very fine white sand.	417	86	503	17.1 %
Namba .. Mar. 1914	Vegetable debris ..	76	0	76	—
Mbugwe .. Mar. 1915	" " .. ..	55	0	55	—
Kiuwa .. Feb. 1914	" " .. ..	310	7	317	2.2 %
Karambidi Sept. 1914	" " .. ..	76	3	79	3.9 %
Limnaiba . Sept. 1914	" " .. ..	268	15	283	5.3 %
Mugogoya Sept. 1914	" " .. ..	77	8	85	9.4 %
Mbugwe .. Sept. 1914	" " .. ..	62	24	86	27.2 %
Nsadzi .. Feb. 1914	" " .. ..	55	25	80	31.2 %
Total and average in sand .. ..		9044	826	9920	7.0 %*
" " " " vegetable debris ..		979	82	1061	9.9 %*

\* Average by localities.

A yet more striking case of this same sort was observed in the interior of Bugalla Island, where a surface of hard clay was very thinly strewn with gravel. Shelter and surface conditions were very attractive to the flies, and it is probable that many larvae were deposited there, but though an occasional perfectly fresh puparium—formed the same day—was found, no shells or old puparia could be found on any of the several occasions the point was visited. It appeared to be a perfect death-trap.

First and last, a considerable number of experiments were made in the planting of puparia in localities where none could be found, but where it was conceived they might be deposited by females which could find no safe and attractive breeding places. These experiments proved that certain places—notably tufts of a certain species of grass—would afford adequate protection to the puparia if the flies had the prescience to select them. They also proved that in many places which the flies might conceivably select in lieu of better, the puparia would almost certainly be destroyed.

It was concluded rather definitely that the fly would be exterminated by the predatory destructors of puparia if the females were to deposit their young in the massive shelter—i.e., in forest or forest-like shelter—which they require as protection for themselves. It is most especially in such places, where the surface of the soil is covered with dead leaves and leaf-mould, that the puparia are found and destroyed by predators.

### IX (d). Inanimate Destructive Factors.

#### (1). Sun.

There are very few insects which can withstand for long full exposure to sun, and *Glossina* is no exception. Flies have been inadvertently killed through less than half an hour's exposure of the cage in which they were confined. The cage rested on sun-baked earth, however, and if unconfined the flies could probably have lived much longer. But shade, and of a substantial sort, is requisite during the heat of the day, and flies cannot be tempted far from it when the sun is at maximum power.

Sun striking on soil in which puparia are buried no more deeply than the larvae naturally penetrate—rarely more than  $1\frac{1}{2}$  or 2 inches—will destroy them quickly.

It not infrequently happens that a week or a fortnight of dry weather will destroy—or at least cause to droop and wither—herbaceous vegetation that previously afforded attractive and adequate shade for breeding grounds, and great numbers of puparia, in the aggregate, are destroyed by drought and sun in this manner. The most curious case was encountered on Tavu Island in September 1915. Very attractive breeding grounds, adequately protected by shrubs of a sort known to the natives as “Kinsembwe,” had been exposed by the activities of a defoliating caterpillar (a species of *Acraea*) and quite extraordinary numbers of puparia were destroyed. Game breaking down vegetation at breeding grounds on Bugalla Island produced the same effect on a smaller scale.

All things considered the sun must be regarded as the most destructive—potentially—of any “enemy” of *Glossina palpalis* and the one against which protection is most urgently required.

#### (2). Storms.

Light shelter is sufficient protection against sun, for both pupae and adults. Massive shelter is nevertheless certainly necessary to the species, and the one destructive agency against which it is obviously of much greater protection than light shelter is storms.

It is very difficult to study the effect of storms on adult flies—mainly because they are almost impossible to find except when active. One can only be sure that their hiding places have been discovered by searching at hours when none are active—for they are quick to take flight if disturbed and quickly confused with active flies if there are any about.

It is a strongly marked characteristic of the active flies to seek shelter when a storm is brewing, especially the females, as shown by the accompanying graph (fig. 10), which was secured in the course of an experiment with the streams of moving flies. The catches were made at a point when all the "resident" flies had been caught off, and only those in the passing streams were being caught. About 11 o'clock a storm gathered on the horizon. The temperature fell a few degrees, and a light breeze sprung up. This was all that happened. The sun was not obscured, and the storm did not come within miles of the island (Manene, 17th March 1915), but almost half the females sought shelter, and remained secluded until the cool breeze dropped. Then they quickly became even more active than before.

Certainly the insects would not flee so quickly at first signs of a storm unless they were fearful of it, and next to sun, storms are probably the most dangerous "enemy" of the species.

### (3). *Flood.*

The rising waters of lake or stream may destroy many puparia in breeding grounds in sand or gravel deposits, and would destroy many more than is in fact the case were it not that the females avoid depositing their larvae in spots too near the water. Even on the "fly beaches" it is in the old beach line beyond reach of even the heaviest waves that nearly all the large deposits of pupae have been found.

The effect of such a flood tide as that of 1906 upon the puparia must be very destructive, for in May and June of that year there could have been very few good breeding places—relatively—beyond reach of the waves (see p. 457).

In the bed of the Victoria Nile, some miles from its source, excellent and much frequented breeding grounds were found (April 1914) at points where they would almost certainly be destroyed in May or June.

### (4). *Fire.*

Bush or grass fires are potent factors in the bionomics of *Glossina morsitans*, but at no point visited on the islands or riparian zone of Victoria Nyanza was fire likely to affect *Glossina palpalis* to an appreciable extent.

## IX (e). **Secondary Environmental Factors detrimental to *Glossina*.**

Whatever benefit may be derived by humanity from the activities of the two natural enemies of *Glossina palpalis* which produced an appreciable effect on its density—spider and dragonfly—is inseparably associated with whatever it is which permits these entomophagids to multiply to such excessive numbers as is required to produce that effect.

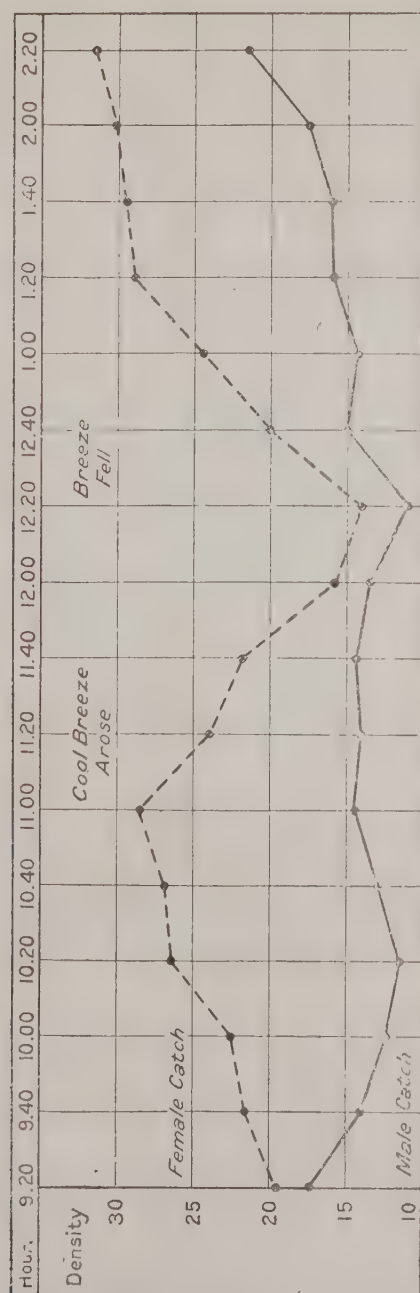


Fig. 10. Diagram showing effect on activities of *Glossina palpalis* of a storm passing at a distance.



Nothing but "insularity" could be attributed as the determining factor in the case of spider. Its great abundance is partly due to the incredible numbers of "lake flies" (*Chironomus*, mainly) which breed in the lake and frequently rise from it in such swarms as to appear like the smoke of a large steamer on the horizon. Swarms of them that must number thousands of millions gather and sweep on shore, where, if there chances to be a generation of newly hatched spiders coming on, they provide an abundance of food at a critical time. Possibly there is some correlation between the incidence of lake fly and of spider, which works out to the disadvantage of *Glossina* in the end.

There is less mystery in the case of the dragonfly. The particular species before mentioned feeds as nymphs in shallow, rush-grown water, more particularly where there is sand and pebbly bottom. The existence of such shallows off shore is detrimental to tsetse on shore.

The *Bembex* breeds in fine, dry sand, of a sort that it can burrow into without its galleries collapsing. It is very irregularly distributed, because this type of soil is not at all common. The type is mildly detrimental to tsetse where it occurs.

Absence of rock, both on shore and in the shallows off shore, is a more potent factor in its inimical effect on tsetse, for *Varanus* is a rock-dweller on land, and its most favoured food is the crabs and molluscs—especially the crabs—which are only found in rocky shallows. There are long reaches of sandy shore south of Dumo village, in Buddu, which are virtually free from fly because of absence of food; only crocodile occurs, and only at a few points where buck comes down to the water are flies and crocodiles likely to meet.

No trace of *Varanus* was seen along these reaches. Had it occurred (*i.e.*, if there had been food for it, and a rock-bound bottom), its inland wanderings across the natural clearing that bordered the shore would have brought it into contact with shelter and breeding places, and conditions of life would have been excellent for tsetse.

#### IX (f). Leopard as a Deprivative Enemy of *Glossina palpalis*.

Through a combination of partly fortuitous circumstances it is possible to measure or estimate, roughly, the effect of the presence and activities of leopards in restricting the range and density of *Glossina palpalis*. It is plainly a more efficacious deprivative enemy than spider is a destructive enemy of the insect. The data follow, item by item.

(1). On the Sesse Islands there are no leopards or other large beasts of prey. Following elimination of the human factor situtunga increased at a rapid rate on every island where it occurred, and spread from the marshes to the hills and abandoned plantations. As a result the range of fly inland increased from a low average of perhaps 300 yards—not counting stragglers—to one that is at least 5 times greater wherever shelter is good and continuous for this distance inland.

(2). On the two sudd-bound islands of Bunjako and Binga leopard occurred, and also situtunga. There was no increase of the latter, nor could evidence be found on Bunjako, which is densely fly-infested along its shore, of more than ordinary extension of infestation inland.

(3). On the island of Bussi, largely sudd-bound, but previous to 1909 separated from the mainland by a canoe track through the sudd, no leopard formerly occurred. The canoe track was choked by sudd, however, and leopards crossed it soon after the eastern shore of the island was depopulated. In October 1914 the island was surveyed for game and inland infestation by fly. Nowhere else were the excreta of leopards discovered in such extraordinary quantity, and examination of them—exact figures were not kept—disclosed unmistakable remains of either *situtunga* or monkey in nearly every case. No other traces of *situtunga* were found on the island except, as is usual on the mainland, along the borders of the sudd-fields. There was no inland extension to the infestation by fly, which was fairly dense along the shore.

(4). Zinga Island was sudd-bound like Bussi, and like it, separated from the mainland by a canoe track. It was said by the natives to be entirely free from leopards. *Situtunga* increased to very large numbers, as on the Sesse Islands, and extended its range inland. The range of fly was also extended inland up to at least 1,000 yards. In exploring the island for inland infestation in August 1915 fresh excreta of leopards were found, and examination of the old canoe track showed that it had become broadly choked with sudd. If the history of the incursion of leopards in Bussi is repeated, the animals should become very numerous by about 1920; *situtunga* should be driven back into the protection of the sudd-fields, and monkeys, which were excessively numerous in 1915, should be greatly reduced in density.

(5). At no point on the mainland has *situtunga* increased to much, if at all, beyond its former density, nor has it extended its range beyond easy reach of the animals from the protection of sudd-fields and marshes.

(6). At about three points on the mainland where the local environment affords exceptionally good protection to bush-buck, inland extension of infestation by fly corresponds to that on islands where leopard is absent and *situtunga* has increased to exceptional density.

There can be no doubt that the range and density of *situtunga* are controlled by the leopard, which is unable to harm it in the protection afforded by sudd-fields and marshes, but which hunts it assiduously along the border of these protected precincts. There can be little doubt that the range and density of bush-buck are controlled in the same manner; protection in its case being provided by densely tangled thickets, through which it plunges with strange facility, and within which no large animal can approach it without betraying itself.

Wherever leopard is absent and *situtunga* present in sufficient density, range of fly is extended inland, and *situtunga* has increased or is increasing (if present at all) everywhere that leopard is absent. There is every reason to assume that bush-buck would do the same, in the absence of leopard and of human hunters.

The correlation is perfect at every point, and it is an entirely reasonable conclusion that in the absence of leopard inland range of fly would on the average be as extensive along well protected portions of the riparian belt as on the islands where *situtunga* has increased or as at the few points along the mainland shore where the bush-buck has found exceptionally secure protection.

There would be inland extension of infestation to approximately 5 times its present depth at many points, and along extensive reaches of mainland shore, if it were not

for the deprivative effect of the activities of leopards. They are certainly a more efficacious natural enemy of the tsetse than spiders, or than any other destructive enemy that has been identified.

#### IX (g). Relations between *Glossina palpalis* and other Biting Flies.

The data secured during the experiments with cattle described in Sect. VI (c) (Table XXV) indicated that the presence of other biting flies than *Glossina* might have an effect on host animals that would effectually prevent *Glossina* from feeding upon them. This has since been confirmed in various ways; partly by a series of observations on the behaviour of domestic animals, or of animals in Zoological Gardens, under attack by flies of various species. The Zoological Park at Washington affords particularly good opportunities for such observations, being situated well out from the city in a naturally wooded ravine where *Stomoxys* and *Tabanus* are numerous. Not less than 25 species of ungulates occupy paddocks that are badly infested by these flies, and various others, including several of the familiar game animals of Africa, have runways that are partly exposed.

Variations in degree of tolerance or intolerance to attack were very remarkable, ranging from the absolute intolerance of Barbary sheep, which would seek the seclusion of their hut at the approach of a single *Stomoxys*, to the phlegmatic indifference of red deer, and wapiti, which would permit *Tabanus* to engorge without serious protest. But there was no animal that was not roused to protest and retaliation if flies became too numerous and persistent, and any animal that is thoroughly aroused and excited becomes of little value as a host to any biting fly.

Eland, for example, was passive under attack by *Stomoxys* in moderate numbers, but repeatedly on approach of *Tabanus* the animals would betray annoyance, and move to protect themselves not only against the greater but the lesser pest. A single *Tabanus* would cause all the elands to seek shelter, and effectually deprive several dozen *Stomoxys* of this particular source of food. Bison was more tolerant than eland, but a few *Tabanus* would sometimes set a whole herd in motion. Zebra and wild horse were less tolerant than eland, but would suffer *Stomoxys* to feed in small numbers until *Tabanus* appeared.

None of the larger biting flies observed on these or any other occasions have pressed their attack on an unwilling host regardless of risk to themselves, but none has shown more regard for its own safety or been quicker to desist from attack upon an intolerant host than *Glossina palpalis*. A *Tabanus* has been observed to return to the attack more than 30 times before admitting defeat. A *Glossina*, unless positively famishing, doubtfully returns more than 4 or 5 times at the most—perhaps not more than once or twice. With man they usually desist after the very first repulse. The more persistent pest may, therefore (as shown by the experiment—Table XXV) become a very efficacious deprivative enemy of the less persistent and the effect is felt in two distinctly different ways:—(a) the host animal may be induced to leave a locality or district where it is liable to be annoyed, or (b) the less persistent and more easily discouraged flies may be induced to leave the locality where a more persistent and annoying species is active.



The dependence of *Glossina palpalis* upon specific forms of protection—breeding grounds and shelter—has been shown in Sects. VII and VIII. Except when provided with both kinds within easy reach (of the flies) from each other the species cannot exist. Where both kinds occur in sufficient proximity the fly can exist if also provided with food, but food, also, must be within easy reach of flies from both kinds of protection.

It is this factor of the actual location of food with respect to protection that counts most heavily in determining the range and density of fly. It is much less a question how much food—how many host animals—exists in a given region or district, or on a given island, than it is one of the quantity of food or number of host animals existing in the adequately protected precincts. It is not necessary that the host animals shall be destroyed in order to injure the fly; but is quite sufficient that they should move a little outside the range or reach of flies from either shelter or breeding places.

Therefore if the animal is induced by *Tabanus*, or any other biting fly, to move a little farther away from the specifically protected precincts, *Glossina* is forced to follow, and in following is exposed to all the risks, and enemies of a destructive nature, that make specific protection a requisite for its existence. The effect of the rival is precisely equivalent to either of the following:—(a) reduction in quantity of available food, (b) reduction in quantity or degree of protection, or (c) increase in number or destructiveness of enemies.

This is if the host is induced to leave the locality. It is the same if retaliatory activities on the part of the host induce the flies to desist from attack and to move on in search of another, more submissive animal. To do this the flies must leave protected precincts and undergo greater risk of being destroyed themselves, or of being unable to find protection for their young.

The activities of *Tabanus* have the direct effect of reducing the quantity of available food in protected precincts, which is the equivalent of either reducing the amount of degree of protection, or increasing the number or destructiveness of enemies.

#### IX (h). **Super-density of *Glossina palpalis*.**

There appears to be nothing to prevent the multiplication of *Glossina palpalis* to any degree of density which the food supply permits in any locality where protection is provided for it, except the continued dispersion of flies outwards from the protected precincts to infest a surrounding zone of unprotected territory. Within the protected precincts the natural increase of the species is greater than the mortality, but gain through natural increase is equal to loss through mortality plus loss through dispersion. Hence density does not increase beyond certain limits, because when the flies become sufficiently numerous to arouse their host animals to the point of retaliation, the immediate effect is to accelerate dispersion, thus reducing density in the protective precincts. Outside these precincts mortality is greater than reproduction, but loss through mortality is equal to gain through natural increase plus gain through immigration.



A delicate "natural balance" is thus created, which remains in a state of great stability as long as nothing interferes with the free dispersion of flies. Super-density (or "outbreak" or "epidemic") of fly is impossible. It cannot increase so as to cause direct injury to its host species through excessive blood-letting; it cannot even increase so as to cause its host animals excessive annoyance.

But if dispersion is for any reason obstructed or interfered with, the mechanism of the balance between the fly and its host species is thrown out of gear, and its density continues to increase until in their own protection its hosts are forced to abandon their haunts. The fly thus becomes an "enemy" of its hosts in actuality. It has "broken out" or become "epidemic," in the terminology of economic entomology. It has increased to a state of super-density when the flies have become the real deprivative enemies of each other, just as flies of the genus *Tabanus* may become the deprivative enemies of tsetse-flies. One tsetse can be the deprivative or competitive enemy of another as easily as a *Tabanus* can be the enemy of a tsetse.

On a very few occasions only were such conditions found to prevail in the region covered by these investigations. The first instance was on the island of Kimmi, which alone of all the islands visited—some 70 in all—appeared to constitute almost entirely a protected area. There was no opportunity for dispersion from it unless the flies struck out over open water, which they were plainly loath to do, and there was hardly a spot on the island where the flies could fail to find both shelter and breeding grounds within easy reach. There was no apparent reason why density should not increase under such circumstances to the point of super-density, which would either injure the host animals or force them to abandon the district.

Conditions encountered on this island in January 1914 indicated that something of this sort was actually taking place. The infestation was heavy (37.2 according to methods finally accepted for estimating male density) and the female percentage was very high (63.5 in total catch and 55.3 at the lowest estimate). The flies were as ravenous as the sex ratio indicates, and host animals seen during 3½ days spent on the island by Dr. Carpenter and me totalled a single *Varanus* seen by him and a single hippo heard crashing about in a reed thicket by me.

No crocodiles were seen, but there was abundant evidence of their very recent presence in the form of nesting places with hatched egg-shells, and runways through the reed fringe along the fore-shore. There was also plenty of evidence of the recent presence of *Varanus*, the mounds thrown up by which were more numerous on this than on any other island visited, except Manene. It seemed not at all improbable that the fly had actually increased to such super-density as to force even the crocodiles to abandon the island, temporarily, until the density of the pest should be reduced.

This idea was sustained by the failure of the experiment cited in Sect. VI (c), Table XXIII (p. 402), in which tethered crocodile and *Varanus* (on this same island at this same time) became so quickly intractable under attack that experiments had to be discontinued.

The idea also suggested the following experiment:—

If, as appeared probable, super-density of fly had caused the host animals to abandon the island temporarily, the sudden deprivation of food would result in a

quick fall in the number of young produced.\* If such decrease in rate of reproduction had taken place within the period of 3 to 4 weeks required for the pupal stages, the fact would be disclosed by examination of the puparia, and the proportionate numbers of them found in early and late stages of development. At a certain late stage in development the pupa is found within the puparium shell showing traces of adult coloration. Such pupae must have been from larvae deposited at least two weeks before. In freshly formed puparia the pupa is unrecognisable, and it requires at least two weeks for it to form and to acquire colour, except in the eyes, which are coloured almost as soon as it takes recognisable form. A count of late and early stages of puparia collected at various points on Kimmi Island was therefore made, and as a check upon it some 3,000 puparia collected in various other localities were examined and counted to ascertain the normal proportions.

The normal, as indicated by the check, was 27.3 per cent. late stages, but on Kimmi Island the late stages composed 46.3 per cent. of the total found and examined. There should have been—if the normal is correctly calculated—very close to 16 early stage to 6 late stage puparia; actually there were only 7 early to 6 late, indicating that less than half as many young were being produced at the time the collection was made as were being produced two to three weeks before.

In March the island was revisited, the infestations measured, and a second search made for puparia. Conditions were changed notably. Density was somewhat lower than in January, but food had become more plentiful, female percentage had dropped to a figure not far above the ordinary, and the flies were no longer ravenous or especially troublesome. The examination of puparia disclosed only

TABLE XXXVIII.

*Showing Variation in Rate of Reproduction (Number of Young produced) of Glossina palpalis as reflected by Proportion of Late and Early Stages of Puparia.*

Analysis of finds of puparia.	Kimmi Island.  January 1914.	Total and averages from numerous localities (1) (showing normal).	Kimmi Island.  March 1914.
No. of puparia found .. .. .	188	3615	155
No. of early stages .. .. .	101	2626	130
No. of late stages .. .. .	87	989	25
Percentage of late stages .. .. .	46.3 %	27.3 % (2)	16.1 %
Ratio of late to early .. .. .	1 : 1.16	1 : 2.66 (2)	1 : 5.20
Excess or deficit, early stages . . .	— 56 %	0	+ 95 %

(1) See Sect. VII (a), Table XXVII.

(2) This ratio would be a constant if the rate of reproduction of the species (number of young deposited) did not vary.

\* The females nourish the young larva until it is full fed and ready to transform into the pupa, equal in size to herself. Normally she must feed (engorge) at least 3, probably 4 and possibly 5 times in order to provide sufficient food for a single larva.

16.1 per cent. of late stages. There should have been 16 early to 6 late stages, whereas there were found approximately 32 early to 6 late, or almost exactly twice more than normal, indicating that the flies were depositing twice as many young as were being deposited two or three weeks before.

The experiments were conducted with sufficient care to eliminate most chances of error, and little doubt is felt that there was actually a falling off in the number of young produced followed by a proportionately heavy increase in numbers. The only question is whether this falling off was due, as assumed, to the temporary abandonment of the island by host animals, and whether this in its turn was due, as assumed, to increase in density of fly. The experiment turned out exactly as it should, in accordance with the working hypothesis. It sustains the hypothesis, though it does not prove it. The point in question is, in fact, one that could only be proved by investigations conducted over a considerable period on an island like Kimmi, with exact observations on the movements of host animals and variations in degree of infestation.

TABLE XXXIX.

*Showing Variation in Infestation of Kimmi Island between January and March 1914.*

Observation point.	Infestation in January.			Infestation in March.		
	Catch.	Male density.	Female percentage.	Catch.	Male density.	Female percentage.
S.W. Point .. ..	384	23.3	62.9 %	208	19.1	26.8 %
N.W. Point .. ..	272	43.3	52.2 %	502	45.6	27.3 %
S.E. Point .. ..	506	39.5	53.2 %	351	31.7	27.4 %
Southern Shore ..	276	42.7	53.0 %	292	31.5	13.7 %
Totals and Averages ..	1438	37.2	53.3 %	1353	32.0	23.7 %

The only other localities visited in the course of these investigations in which the female percentage was in excess of 50 (for the entire island or district) are:—

- (1) Bunyama Island (data mislaid\*) .. .. .
- (2) Bale Beach and Mujuzi Creek colony .. .. 64.6%
- (3) Bukakata South colony .. .. . 51.0%
- (4) Kaziru District (Buddu) .. .. . 50.6%

\* Since recovered, but not included here.

In none of these localities did it appear that scarcity of food was due to density of fly. The fly was suffering from want of food, certainly, but merely because there was so little food and this so hard to find. Conditions were as they would become on Kimmi if the host animals abandoned the island permanently, all save two or three *Varanus* or a single crocodile. The point where food chanced to be, at any time, would then be a "colony centre"—exactly like the colony centres in the

Bwendi district (fig. 6, p. 411) or at Mujuzi Creek, and there would be dispersion from them as from the points in the Bwendi district or from the point at the mouth of Mujuzi Creek where crocodiles harbour (p. 388), or in Bugaba Island where breeding ground marks the colony centres (p. 423). There can be no super-density of fly except under exactly such conditions as prevailed at Kinuni when there is food generally distributed throughout the island, shelter and breeding ground within easy reach of food, and no opportunity for dispersion. There may be starvation and famine, and a greatly reduced reproductivity, but it cannot be induced by the fly's own activities, unless (1) conditions of life are locally favourable to increase, and (2) dispersion from the locality is arbitrarily restricted.

#### X. GENERAL CONCLUSIONS.

There are three specific requisites to life of *Glossina palpalis*, one *sustentative* and two *protective* :—good shelter and breeding ground. One kind of food, the blood of vertebrates, suffices for the insect in all its stages. The two kinds of protection serve adults and pupae respectively.

All these appear equally requisite. There is some slight evidence that other food than blood may be taken, but none concerning its nature, and no evidence that any other is required. There is much evidence that blood is absolutely required—as supplied by the experiment cited in Sect. II (*b*), and the effect upon behaviour of flies of depriving them of their normal food supply; by the apparent reduction in rate of reproduction and in density of fly on Kimmi Island associated with obvious shortage of food (Sect. IX (*h*)); by the long-shore distribution of fly in the Bwendi district as described in Sect. VI (*g*); by the distribution of fly in the Mujuzi Creek district (note to Sect. III (*e*)), and in various other cases. No one of these cases, of itself, would establish the fact, but the cumulative evidence is all to one effect, and the mass of it convincing.

The absolute necessity for the kind of protection that is provided by breeding grounds is particularly well shown by the fly survey of Bugaba Island (Sect. VI (*g*) and fig. 7). This was confirmed by similar surveys of Bubembe and Bunyama Islands, which have not been included herein for the sake of brevity, and by observations many times repeated. It is not requisite that the breeding grounds should be in sand or gravel—fine, dry vegetable debris will serve as well; but it happens that the sand and gravel breeding places are most extensive in this particular region, and more attractive than any other, so that very much the larger number of flies breed in them.

A surprise was the discovery that “massive shelter” is requisite to the life of this fly. This discovery was entirely unexpected, and for a long time it seemed incredible that absence of massive shelter should be the explanation for absence or relative scarcity of fly on the islands cited in Table XXXIII (p. 428). Cumulative evidence finally dispelled all doubts—notably that supplied by the study of the Lutoboka Bay colony (fig. 9, p. 431); by conditions along the southern shore of Buganga Peninsula (Table XXXIV, p. 432); and various other less striking cases not cited in these pages. There could be no doubt, in the end, that the light shelter that is most attractive to the active flies, and which also serves in the majority of cases to shade breeding grounds, is insufficient to protect the inactive flies from destructors, animate or inanimate, as the case may be.



Apart from these things the insect appears to require nothing except that which is inseparable from an equable, tropical climate. It is believed to be pure coincidence that the insect is never found far from water, and it is confidently believed that it would exist, and that it will be found eventually to exist, in any inland localities where host animals of favoured species occur in well sheltered areas provided with suitable breeding places. In fact the interior infestation on Mbugwe Island, described on page 384 and mentioned in several other connections, is believed to be a true inland colony, such as might occur equally well at any distance from lake or river under a comparably favourable (and extremely unusual) combination of circumstances.

The three requisites being equally indispensable, it follows that in the absence of any one the species cannot exist. All three must be present in proper combination, and local density is likely to be governed by the quantity or amount of whichever one of the three is least abundantly provided :—

(a) by amount of food, if protection is more than sufficient, relatively ; (b) by amount of shelter, if food and breeding ground are both more than sufficient, relatively ; and (c) by amount of breeding ground, if food and shelter are both more than sufficient, relatively.

This is indeed the case. In the Bwendi district (Sect. VI (g)) shelter and breeding grounds were both very good and extensive, but food was very scanty and density of fly low ; along the southern shore of Buganga Peninsula, (p. 432, Table XXXIV) food and breeding grounds were both good and plentiful, but shelter was poor or lacking, and density of fly was therefore low ; on Bugaba Island (p. 424) both food and shelter were good and plentiful, but breeding grounds were poor, or few, and density of fly was low. These are merely specific instances selected to illustrate the general rule, which was upheld everywhere.

A very important question is : What constitutes a proper combination of the requisites to life ? It is obvious that they must occur within the radius of movement and perception of individual insects, from a central point, or from each other ; but this does not answer the question. What is the radius of movement and perception—or it may be called the radius of range or reach—of individual insects ? This question can only be answered empirically, and unfortunately it did not occur to me until nearly the close of the investigations to attempt to answer it. Careful review of field notes, supplemented by memory of conditions not accurately described, leads to the tentative conclusion, that unless all these requisites to life occur within a radius of less than 100 yards from a central point, the conditions of life are so unfavourable that the species cannot exist.

This does not mean that territory deficient in one or more of the requisites to life is never infested. On the contrary, in the major portion of the infested territory conditions of life are unfavourable to the existence of the species, and these portions owe their infestations to their contiguity to territory in which the life requisites occur in proper combination, and which thus becomes a centre of infestation for a considerable zone surrounding. Within these centres natural increase of fly from generation to generation exceeds mortality, but in addition to loss through mortality there is loss through emigration or dispersion of flies into the surrounding

zone where conditions of life are positively unfavourable. In this surrounding zone loss through mortality exceeds gain through natural increase, but in addition there is gain through immigration from the centres of infestation. A perfect "natural balance" is thus established and perpetually maintained, so long as flies are free to disperse from the infested centres into the surrounding zone. If dispersion is interfered with, the mechanism of this balance is thrown out of gear; but this very rarely happens in nature so far as I am aware it failed to function in this region only on a few small islands, such as Kimmi, where the conditions of life appear to be so favourable that super-density results at frequent intervals, causing the host animals to abandon the locality temporarily until the density of fly is reduced. Here we have a natural balance constructed on an entirely different mechanical principle, which operates as effectually, but not nearly so smoothly, as in the majority of cases, in which it is the flies and not the host animals that are moved to disperse from over-densely infested localities.

The rôle played by natural enemies and destructive factors generally is to destroy the insects, and to prevent the existence of the species everywhere beyond the limits of dispersion from protected localities. The protection of shelter and breeding grounds suffices against all destructive factors, animate and inanimate, except possibly and very rarely, against extraordinary numbers of spiders or dragonflies. The protective factors in the bionomics of the species are far more specific in their nature, and easily studied, than the destructive. It is, therefore inadvisable to study the destructive factors specifically. It is possible to utilise them for controlling the density of the pest easily enough by merely depriving it of its specific protection against them, but altogether impossible to expect them to penetrate protected precincts, or to utilise them otherwise than in the manner indicated by the facts.

It is possible to argue successfully that the species is normally controlled in range and density by the amount of *available* food, provided that the word "available" is broadly enough interpreted. Food, to be available, must be within reach of the insects from protection (of both sorts). It is also necessary that the host animals should be complacent under attack, for there is no host of the insect which cannot protect itself against attack if it will. Monkeys are "unavailable" as hosts, not because their blood is less suitable as food, nor because the flies are unable to draw it, but entirely because the animals are so active in protecting themselves. Sheep and goats are more complacent and less active in protecting themselves than monkeys, but much less complacent and more actively self-protective than oxen or antelopes. Men vary greatly in temperament, but the average man stands between goats and sheep on the one hand and oxen and antelopes on the other. The large reptiles are the most complacent of all, and most available as hosts, despite the fact that the flies experience measurably greater difficulty in drawing blood from them. Availability of food thus varies greatly with the species, and with the temperament of the individual host, and also with circumstances and conditions of time and place. If large Tabanid flies are annoying oxen, they become less available as sources of food; if *Glossina* itself increases in local density, its host animals become less available. This is strikingly exemplified by human behaviour. If there are very few flies a man pays little or no attention to them, and they have

relatively little difficulty in feeding; but if there are very many flies, the man provides himself with one or two fly switches, and they have proportionately greater difficulty in feeding.

Availability of food is also measured by the precise location of host animals with respect to protection. If separated from shelter by as much as 20 yards of unsheltered terrain, food may be entirely unavailable to the flies. This was proved by conditions along certain reaches of shore in Buddu, where there was abundance of crocodiles along a sandy beach separated by from 20 to 100 yards of grass land from shelter and breeding grounds. The flies could not perceive the hosts at this distance, and they do not freely range so far from shelter in search of food.

The factors which operate naturally and control the range and density of *Glossina palpalis* in this region are, mainly, as described above; the factors which can be operated by human effort to reduce obnoxious density to within innocuous limits are identical. It is useless to contemplate destructive control measures. We can see from the experiment and observations made on the "spider islands" that it requires an immense amount of destruction by specific agency to produce a measurable effect on the density of the species. The spiders on Wema Island actually destroyed enormous numbers of flies, but for the most part these flies would have been as promptly destroyed by any one of various other agencies in the absence of the spiders. If the spiders are about, the flies increase to slightly greater density, and then, through wider dispersion, run greater risks and the natural balance is struck at a slightly higher level. Or, stating the same truth in another way, the main effect of artificial or unduly heavy natural destruction of flies by any specific agency is to make conditions of life much more favourable to the rapid multiplication of the survivors. It is wholly impractical to consider any control measures involving artificial destruction of flies, and wholly necessary to rely upon measures designed to deprive the insects of either food or protection or to render food less available to them.

For reasons in part set forth in Sect. II preceding it is regarded as inadvisable and even dangerous to contemplate control of the pest through depriving it of food. It is probable that if completely deprived of all favoured hosts it would be unable to exist on hosts favoured to a no greater degree than sheep, goats and man, but it is probable that it would continue to exist if cattle or pigs were provided. It is also certain that where favoured hosts are plentiful, man is almost immune to attack, but that when they are few man is freely attacked, and our object must always be to protect man rather than to destroy flies.

There is no such objection to the proposition of controlling fly through depriving it of protection, and it is on measures designed to this end that we must chiefly rely. They are the clearing measures already in use, and they have been proved efficacious on many occasions. The maximum of economy and efficiency is to be gained through clearing at precisely the right points—i.e., at the centres of infestation wherein natural increase of fly is most rapid. By clearing these the dispersion of flies into the surrounding zone is prevented, and the effect is general. By clearing in the zone infested by immigrating flies the effect is local at best. A small amount of clearing at the centres of infestation may be much more effective than a large amount of clearing away from them.



It is useless, however, to discuss ways and means for reducing obnoxious density of this pest until some decision has been reached concerning what constitutes obnoxious density. It has been shown by three investigations that the density of infestations by this insect, as measured by the males to be caught "per boy per hour," ranges all the way from less than 0.1 to more than 150.0. A locality is no less truly infested if density is 0.1 than if it is 150.0—the difference is wholly one of degree. We know that a density of 0.1 to 1.0 is innocuous, because density in populated districts along shore appears never to have been reduced below these figures, despite which human trypanosomiasis formerly prevalent—when density was much higher—seems completely to have disappeared. There is good reason to believe that a density of 6.0 is ordinarily safe and sanitary, but that one of 15.0 or 20.0 would ordinarily be dangerous. Admittedly it would be desirable for purely sanitary reasons to reduce density to 0 everywhere, but the expense would be so enormous as to render it completely impracticable. Practical measures must combine efficiency with economy, and the most economical measures are such as do not carry reduction in density of the pest beyond what is necessary for sanitary reasons.

#### XI. EFFECT OF FLUCTUATING LAKE LEVEL ON GLOSSINA PALPALIS.

In Sect. VII (e) mention was made of the effect of fluctuating lake-level on range and density of *Glossina palpalis*. Following are data bearing on this point, which could not well be included in that section, and from which certain conclusions may be drawn, as presented.

##### XI (a). Fluctuations in Level of Victoria Nyanza.

Victoria Nyanza is usually highest in May and lowest in November, with a tendency to rise in December and to fall in February. The average yearly fluctuation is about  $1\frac{1}{4}$  feet. But the movements are very irregular, and in 1906, instead of falling in February it rose steadily from November 1905 until the following May, and reached an unprecedented height. Again in 1910 it failed to rise in December, but continued to fall steadily until it reached an unprecedentedly low level in February 1911. The maximum in May 1906 was about  $4\frac{1}{2}$  feet above the minimum in February 1911, and was nearly 3 feet higher than the maximum from 1911 to 1913 inclusive.

The fluctuations during the ten year period ending in 1913 are shown on a graph recently published by Dr. H. Lyndhurst Duke (Bull. Ent. Res. IX, p. 270).

##### XI (b). Effect of Fluctuations on Shelter and Breeding Grounds of Tsetse.

The high level of 1906 uprooted much vegetation along the shores and washed clean the sand and gravel beaches that in 1913–14 lay some 3 feet higher than and anywhere up to 200 yards inland from the foreshore. Following recession of the water, new vegetation sprung up to shade the newly washed sands and gravels, and ideal breeding grounds were created where none, perhaps, existed before. But already in 1913 and 1914 these new breeding grounds were beginning to deteriorate. Leaf-mould was accumulating and covering the sand, vegetation was massing above it and keeping it cold and damp; and already some of these breeding places had become second-rate or quite unattractive. They were fast becoming like the deposits of sand and gravel that lay beyond the flood mark of 1906, which are nearly always hidden from sight beneath blankets of mould and quite valueless as protection to tsetse.



These were the principal changes that were taking place in the conditions of life for tsetse along the lake shore as a result of the flood tide of 1906 and subsequent low water. At some places the changes were of a very different character, and more kinds of changes were progressing than can well be described in detail. In general, however, it can be stated that wherever the shore rises very gradually, and most particularly at the many points where the gradient is less than 1 per cent., extraordinary changes in the conditions of life for tsetse are likely to follow any such unusual flood as that of 1906. But if the land rises sharply from the water the changes may be insignificant, and usually are of no consequence.

In a general way the island survey had shown that the range and density of fly must have been profoundly affected by the movement of the water, but the real extent of the changes wrought was not appreciated until, in 1915, a fly survey was made of the Buddu shore. This region had been surveyed in August and September 1906 by Dr. Van Someren, whose reports were in considerable detail, and permitted the quite accurate comparison which follows.

#### XI (c). Increase in Density of *Glossina palpalis* due to falling of Lake Level.

The lake shore of the district of Buddu was surveyed for fly in 1906 by Dr. R. Van Someren, working under the direction of Dr. A. D. P. Hodges in the Sleeping Sickness Extended Investigations. This same shore was surveyed by me in 1915, and a most extraordinary change in conditions of infestation was found to have occurred. Following is an extract from the MS. report of Dr. Van Someren, kindly supplied me by Dr. Hodges, paralleled by comments on the present conditions.

##### *Conditions in 1906.*

(Report of Dr. R. Van Someren.)

"When I came to Bale, a little south of Namirembe I found the distribution again interesting.

"Northwards from Bale I found the whole coast some 3 miles up to Namirembe devoid of fly, and from Namirembe for some further 2 to 2½ miles, roughly, into the Gwamba also with no fly.

"After this point one meets them at first very scantily indeed; then in increasing numbers right up to our limit in the Gwamba some 8 to 10 miles from Namirembe.

"For some 3 miles southward from Bale no fly are met with till a small point near the landing place Sekwe (Calcosa) close to Dumo, where I came across them in small numbers and limited practically to this point.

##### *Conditions in 1915.*

(Fly Survey.)

Northwards from Bale the whole coast to Namirembe was found infested to the average density of 6.3. At Namirembe it was very low, but about half a mile beyond the landing it began to increase rapidly, until at points from 2 to 2½ miles beyond it had reached the very high average of 63.5. I have never but twice seen fly more numerous or more annoying (see fig. 11).

After this point the density rises to yet higher figures (76.5, 73.5, 89.5, etc.) and then falls away to moderate figures (5.3, 7.5, 5.5, etc.) but only to rise again later. The average for this 6 to 8 miles of shore is the very high one of 37.6.

For some 5 (not 3) miles southward from Bale to Sekwe the shore is continuously infested, and at 3 miles (2 miles north of Kalkosa or Sekwe) is the centre of the Mujuzi Creek colony described on p. 387 and illustrated by figure 5, with the extreme density of 98.0.

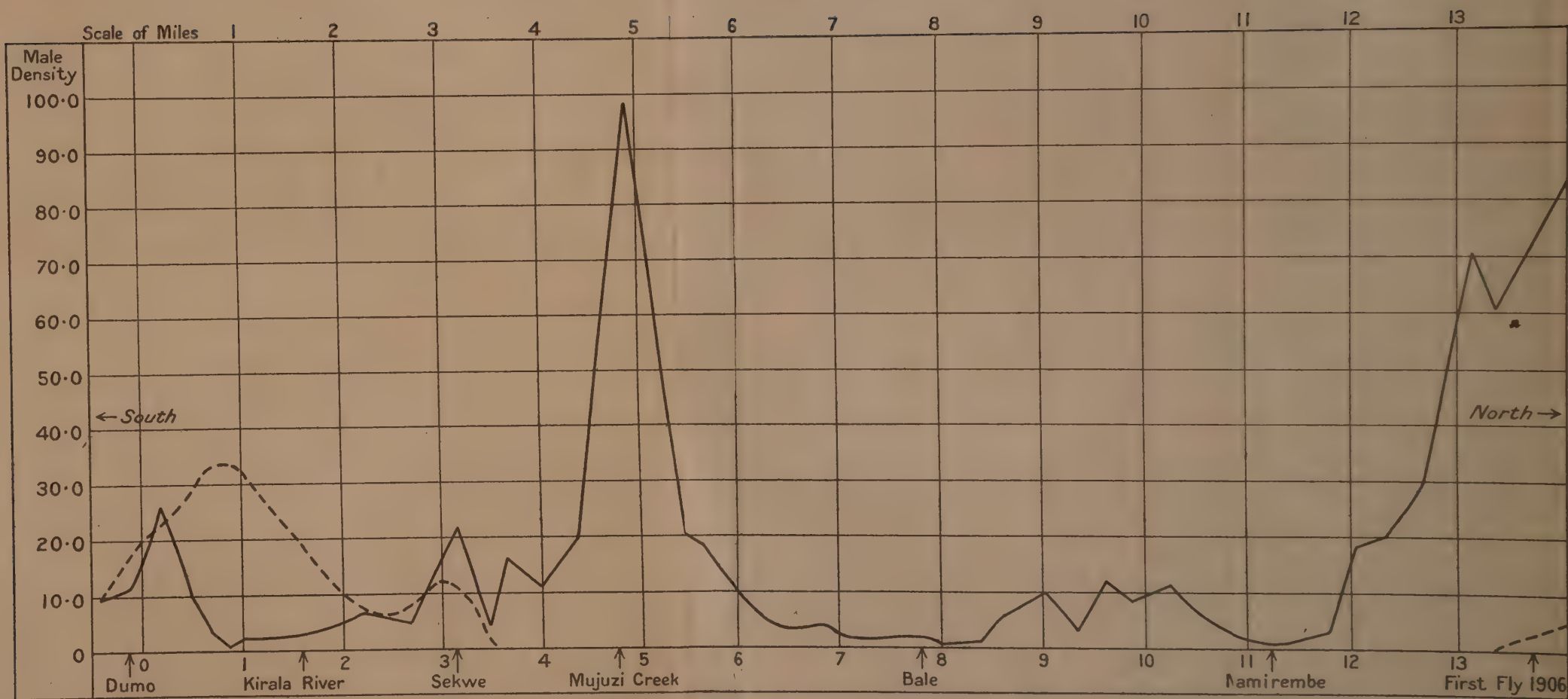


Fig.11. The dotted line shows the occurrence and density of *Glossina palpalis* in 1906, and the solid line in 1915.



*Conditions in 1906.*

(Report of Dr. R. Van Someren.)

"While on one side of the point we caught 8 on the two occasions we waited for them, on the rocks on the other side some 10 yards [rods?] across, where several men and boys were sitting fishing, we did not observe a single fly about their persons, and amongst a group of some 20 drawing a seine a little further along we caught only one the second day.

"The physical conditions in these sections, starting from our limit in the Gwamba southwards, are as follows:—

"A sandy beach extends practically the whole way, except close to Sekwe, where the trees are practically at the water's edge.

"The land behind is low and covered in parts with scrub; in others with larger trees with here and there wide open areas intervening again. At some portions the tree-covered areas are swampy some distance back from the beach.

"At the fly limit north of Namirembe this swampy part comes quite close to the beach and remains so more or less continuously till close to Bale, and continues thus practically to Sekwe, except for portions here and there where the swamp line again comes close to the beach. In many parts the beach is not so high that during high winds the waves wash right over into the swamp.

*Conditions in 1915.*

(Fly Survey.)

The density at these points (Sekwe) averaged 9.2 in 1915—probably not far different from that observed by Dr. Van Someren in 1906, except that it applies to the shore in both directions from the rocks. (These are the only rocks for miles in either direction and identify the locality absolutely.)

The physical conditions in these sections have undergone radical changes owing to the falling of the level of the lake.

A sandy beach is practically continuous the whole way except for the reach of two miles north of Sekwe. Here the beach of 1906 is separated from the present shore line by a belt of marsh, very soft and muddy, into which one sinks knee to thigh deep. Outside the marsh are the beginnings of a new beach, very narrow and wet. Outside of this is a hedge of ambatch, or merinde, that only permits passage of canoes inward to the land at a few points. The old beach of 1906, thus completely cut off from the present waterline, is overgrown with an excessively dense tangle of vegetation. This continues to a point "close to Sekwe" where the trees are still "practically at the water's edge," and (the shore being rocky or falling away steeply) the conditions are virtually unchanged, either physically or, as nearly as can be judged, with respect to infestation by fly.

These conditions are unchanged; there is more of swampy land back from beach than Dr. Van Someren's notes might imply.

The falling water wrought most radical changes in the conditions here described. The beach of 1906 is now high and dry, and there may be 20, 30, 50 or in some places 100 yards of dry sandy embankment between the present beach line and the tree or reed grown swamps and marshes back of it. This almost continuous embankment is partly open in places, and in other places overgrown with dense jungle. Instead of a narrow wet beach with high waves breaking over it, we have a broad sandy embankment with swampy areas "some distance back from the beach," and providing ideal shelter and breeding ground for the fly. It should be added that in 1915 somewhat higher water than for the past few years was working still further changes; building new beaches and cutting off new bits of newly made marsh from the open lake at certain points, and



*Conditions in 1906.*  
(Report of Dr. R. Van Someren.)

"A more or less continuous line of merinde trees occurs some 5 to 15 yards off the shore.

"I formed the opinion therefore that the absence of fly from the point north of Namirembe until Bale could be accounted for by absence of suitable breeding places owing to the conformation mentioned.

"Southwards of Bale however the beach is narrower and fringed with small bushes and apparently suitable for fly.

"I was surprised, therefore, to find none, and cannot account for it.

"This part of the coast is being gradually encroached upon owing to the action of the waves killing the trees and bushes by washing away the soil, which is chiefly sand.

"I repeatedly examined these fly-free areas under favourable weather conditions, but the results were uniformly negative.

*Note on Sex disparity.*

"As regards the relative number of male and female flies I have evidence which I think goes to support Dr. Bagshawe's observations (No. 42, S.S.E.I.) as I have had most favourable opportunities for the purpose.

"On three occasions with the aid of the fly boys we examined simultaneously that part of the Gwamba where numerous fishermen were daily working the sambas, and another part some miles beyond the last net where practically only passing canoes may chance to camp the night. The results were:—

Frequented Area.	
1st day	52 ♂ to 58 ♀
2nd "	40 ♂ to 37 ♀
3rd "	24 ♂ to 29 ♀
Unfrequented Area.	
1st day	75 ♂ to 40 ♀
2nd "	113 ♂ to 68 ♀
3rd "	95 ♂ to 37 ♀

*Conditions in 1915.*  
(Fly Survey.)

cutting away the embankment at others, so that the young trees and jungles growing upon it were being undermined and thrown into the lake.

The new shore line cannot be less than 20 or 30 yards, average distance, outside the shore line of 1906. The old line of merinde trees has mostly disappeared, with only here and there a few straggling survivors or decaying trunks. A new line, continuous or nearly so for some 3 miles north of Sekwe, has sprung up, and at other points a new line is forming.

Certainly the conditions described could not possibly provide good breeding places; neither would the shelter be suitable. Either cause would suffice in explanation.

Southward from Bale the beach is now from 20 to 100 yards from bush or forest with open grass land intervening. Then for rather more than a mile thick jungle grows to the very edge of the water. Beyond this it is open or semi-open to Mujuzi Creek.

In 1915 this reach of shore appeared to be foodless, and the flies dispersing into it from the great colony at Mujuzi creek were plainly famishing (88.8 per cent. of females at one point, see p. 373).

This part of the coast is now (1915) being added to, and the conditions described by Dr. Van Someren prevail at points north of Bale, as noted above.

The catch of fly made over approximately this same territory in 1915 consisted of 768 males to 591 females = female percentage of 43.9.

This compares with the following figures of percentages from Dr. Van Someren's report.

Frequented area:—Males 116 to females 124 = female percentage of 51.7.

Unfrequented area:—Males 283 to females 135 = female percentage of 32.1.

Total catch both areas:—Males 399 to females 259 = percentage of females of 39.2.

Dr. Van Someren does not state the number of fly boys employed or time spent in catching, but it is interesting to note that the flies are about as hungry in the general region now as they were in 1906, there being a difference of but 4.7 points between the figure for the total catches at the two widely separated periods.

As will be seen by reference to the graph (fig. 11), the increase of fly in the region south of Bale and just north of Namirembe has been phenomenal. Below Sekwe, however, the reverse has taken place, as shown by comparison between conditions in 1915, and as they were described by Dr. Van Someren in 1906 in his report for that region.

*Conditions in 1906.*

(Report of Dr. R. Van Someren.)

"The only fly met with (in the region south of Sekwe) occurs along the shore from a point near the village of Dumo northward for about one and one-half miles to the Kirala River, and gradually tailing off from this river toward Sekwe.

From Dumo toward the river the fly is very abundant.

"The range inland (between Dumo and the Kirala river) is practically nil, as the extent of dry land at the lake-side is not more than five yards in width at the broadest part. Inside this dyke is extensive dense forest of kibo palm (*Raphia*) down to the lake-side, standing in very swampy ground.

"Opposite Dumo, where the ground rises fairly sharply the fly crosses a belt of scrub and long grass intervening between lake and village and is found in the plantations immediately bordering the belt. I frequently saw them on women digging in this part.

*Conditions in 1915.*

(Fly Survey.)

The fly still occurs from the same point near the old site of the village of Dumo northward, but its density is notably changed at several points.

The fly is hardly what would be called "very abundant" at any point, but it is not at all abundant from Dumo toward the river. On the contrary, it falls off to a low minimum before the river is reached, and then begins to rise slowly, owing to migration from the colonies at Sekwe and Mujuzi Creek. The infestation at the Kirala River now consists mainly of flies coming in from Sekwe, instead of being at the edge of a centre of infestation with fly tailing off toward Sekwe.

The extensive dense forest still exists, and is still exceedingly swampy, the water at the back of the dyke standing at a higher level than the lake. But instead of coming down to the lake-side there is a belt of exceedingly soft marsh, with grass and a little papyrus lying outside the old beach, from which the open lake is all but completely hidden. The dyke, or beach of 1906, is now a terrible tangle of shrubbery weighted down with rank vines, and with marsh grasses growing rankly along its outer edge. Outside the marshy belt, 10 to 30 yards from the old beach line of 1906, a new beach was forming in 1915. Range inland at this point is noted on page 408. Flies were found on a *situtunga* shot 400 yards from the lake shore.

At the very end of the fly beach described by Dr. Van Someren, where the ground begins to rise fairly sharply, is found the remains of the large colony he describes as existing in 1906. A few hundred yards south the belt of scrub and tall grass—elephant grass—still separates the lake from what were the old plantations. There is now exceedingly dense jungle with occasional openings kept clear by the hippo and permeated with a net work of hippo trails. The fly still penetrates the belt of tall grass, following the hippo trails, which have replaced the foot-paths leading to watering places, and it is now found inland, in the very centre of the old village site (see p. 408 note on inland range at Dumo).

*Conditions in 1906.*

(Report of Dr. R. Van Someren.)

"Just beyond Dumo there is again a forest area for some half mile. Where the forest ceases until the German boundary there is no fly to be found.

*Conditions in 1915.*

(Fly Survey.)

The fly stops at a point only 100 yards beyond that indicated by Dr. Van Someren. But there are several colonies south of the point.

"Of the flies caught in this area 187 were males and 72 females (= 28 per cent. females).

"At Dumo by one of the watering places I caught 20 females to 14 males (= 59 per cent. females).

"On another occasion along the forest up to the Kirala River my boys caught 106 males to 2 females (= 1.9 per cent. females). This is of interest in connection with the physical features. Since fibre collecting ceased there practically no one visits it.

The total catch in this area was 215 males and 184 females, making 46 per cent. females.

At the identical watering place (the only one in the fly area) two catches were made on different days as below :—

Males.	Females	Female percentage.
15	41	73 %
19	57	75 %
34	98	74 %

Along the forest up to the Kirala River the catch of males was identical, 106, but that of females was 86, making 45 per cent ♀.

Again it is interesting to note that sex ratio shows that the watering place, which is (or was) just outside the "belt of scrub and long grass," is now, as it was in 1906, unattractive to the idle males, and is the point south of the colony centre where female percentage is highest. But northward, along the beach where "practically no one" went in 1906, the conditions are absolutely changed.

The foregoing brings out clearly the need for eternal vigilance if any systematised effort is ever made to repopulate the riparian zone and islands, and to protect the population against recurrence of sleeping sickness. There is no more dangerous reach of shore in Africa, perhaps, than that between the points Sekwe and Bale, yet it was perfectly safe apparently in 1906, and the changes have been wrought by the falling of the lake level.

Wherever the shore falls gradually into the lake, similar changes are likely to occur at any time, especially if there is much sand in the district. The danger points can be found by a "fly survey" of the shore, and must be watched to preclude the chance of conditions eminently favourable to spread of the human parasite coming about unknown to sanitary or administrative officials.

**XI (d). Causes for Fluctuation in Lake Level.**

Causes for the irregular fluctuation in level of Victoria Nyanza are, in part, its great size and narrow outlet. From so great an area loss through evaporation must be enormous, and relatively constant as compared with the overflow. The latter represents the surplus of rainfall over evaporation, and if evaporation is a relatively constant quantity, any variations in rainfall are likely to be greatly exaggerated. The surplus not being so very large, it does not require much to double it,

The narrow outlet to the enormous volume of the lake acts like a choked safety valve. Rise in lake level may be very rapid, but fall is more gradual. It seems to have required more than a year for the unusual surplus that gathered so quickly in 1906 to find its way through the walls of rock at the source of the Victoria Nile. If the outlet were not choked in this manner the level of Victoria Nyanza would be somewhat more constant, and the flow of the Victoria Nile somewhat more variable. If it were yet more effectually choked the flow of the river would be more constant and the level of the lake subject to yet wider fluctuations.

#### XI. (e). **The probable Effect of a Dam at the Outlet upon the Tsetse along the Shores of Victoria Nyanza.**

The outlet to the lake into the Victoria Nile is a superb source of water-power, and one of Uganda's great assets. The topography permits its relatively cheap development. There is a natural dam, and excellent opportunity for a canal along the eastern shore of the river, which does not immediately fall away. But a dam would permit a much more complete utilisation of the power that it is as certain to be built as that the economic development of the country will continue.

It is neither a high nor a low level of the lake that creates favourable conditions of life for tsetse, but a fluctuating level. The rising waters clear away massed vegetation and wash clean the breeding grounds; the falling waters permit the growth of new shelter and the breeding of fly in the renovated terrain. Continued growth chokes the breeding grounds, and hides them beneath massed vegetation or the accumulations of mould.

If a dam at the outlet of the lake could be so constructed as to equalise the level of it by permitting more rapid egress of rising waters, it might have a beneficial effect in reducing the density of tsetse along its borders. But the object in building a dam would be the very opposite; it would be to equalise the flow of water in the power canal and the Victoria Nile, and thus to accentuate the fluctuations of the lake.

This might, conceivably, be prejudicial to the fly below the dam, but it would be beneficial to fly above it.

It would be delightful if construction of a dam, and utilisation of the water-power at the source of the Nile could be urged as a sanitary measure, but unfortunately its construction will have the opposite to the desired effect.

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## COLLECTIONS RECEIVED.

The following collections were received by the Imperial Bureau of Entomology between 1st October and 31st December, 1919, and the thanks of the Managing Committee are tendered to the contributors for their kind assistance :—

Mr. E. Ballard, Government Entomologist, Madras :—56 Tabanidae, 8 other Diptera, and 13 Lepidoptera ; from South India.

Capt. P. J. Barraud, Entomologist to the Egyptian Expeditionary Force :—52 Culicidae, 6 Tabanidae, 49 other Diptera, 13 Hymenoptera, 102 Coleoptera, 3 Planipennia, 1 species of Coccidae, 3 other Rhynchota, 4 Orthoptera, and 9 Odonata ; from Palestine.

Mr. C. Beeson, Forest Zoologist :—93 Braconidae and 157 Curculionidae ; from Dehra Dun, India.

Mr. G. E. Bodkin, Government Economic Biologist :—8 Tabanidae, 72 other Diptera, 28 Hymenoptera, 200 Coleoptera, 4 Planipennia, 1 species of Coccidae, a number of Aphids, 16 other Rhynchota, 12 Orthoptera, 22 Ticks, 133 Spiders, 4 Scorpions, 3 Centipedes, and 6 Intestinal worms ; from British Guiana.

Mr. John R. Bovell, Superintendent of Agriculture :—144 Diptera, 37 Parasitic Hymenoptera, and 2 Lepidoptera ; from Barbados.

Dr. S. L. Brohier, W.A.M.S. :—11 Lepidopterous pupae : from the Gold Coast.

Mr. J. H. Burkill, Director of the Botanic Gardens, Straits Settlements :—13 Agromyzid Diptera and 8 Coleoptera ; from Singapore.

Mr. P. A. Buxton :—11 Culicidae, 31 Tabanidae, 16 Coleoptera, 380 Aphididae, and 3 species of Coccidae ; from Persia and Mesopotamia.

Dr. G. D. H. Carpenter :—2 *Chrysops*, 19 other Diptera, 7 Lepidoptera, 170 Coleoptera, 3 Planipennia, 70 Hymenoptera, 2 male Coccidae, 75 other Rhynchota, 19 Orthoptera, and 2 Odonata ; from Uganda.

The Division of Entomology, Pretoria :—22 Hymenoptera, 303 Coleoptera, 26 tubes and 107 slides of Aphididae, and 72 other Rhynchota ; from South Africa.

Dr. Lewis H. Gough, Government Entomologist :—24 Diptera, 52 Hymenoptera, 57 Coleoptera, 12 Planipennia, 6 Rhynchota, and 19 Orthoptera ; from Egypt.

The Government Entomologist, Punjab :—33 Diptera ; from Lyallpur.

Mr. E. Hargreaves :—17 Culicid larvae, 11 other Diptera, 40 Parasitised dipterous puparia, 250 Thrips, 150 Parasitic Hymenoptera, 2 Coleoptera, 51 Coleopterous larvae and pupae, 250 Lepidopterous larvae, 5 species of Coccidae, and 54 Ticks ; from North America, etc. ; 61 early stages of *Pieris rapae* ; from England.

Hawaiian Sugar Planters' Association :—87 Weevils ; from Honolulu.

Dr. J. F. Illingworth :—90 Coleoptera and 2 Rhynchota ; from Queensland.

Imperial Department of Agriculture for the West Indies :—3 Weevils, and 1 pupa ; from Curacao.

Imperial Institute :—3 *Melipona* bees ; from Colombia ; and 6 Rhynchota ; from Dakar.

Dr. Jawara, Jewish Health Bureau :—12 Culicidae ; from Jerusalem.

*Gelding*

Mr. S. Leefmans, Instituut voor Plantenziekten, Buitenzorg :—4 Weevils ; from Java.

Dr. J. W. Scott Macfie :—304 Culicidae, 10 *Pericoma*, 11 *Stomoxys*, 3 tubes of small Diptera, 3 Lepidoptera, and 20 small Leeches ; from the Gold Coast.

Dr. J. M. O'Brien :—1 Queen termite ; from the Gold Coast.

Rev. Father J. A. O'Niel, S.J. :—7 Moths ; from Salisbury, Rhodesia.

Mr. Arthur W. J. Pomeroy :—4 *Tabanus*, 20 other Diptera, 93 Hymenoptera, 69 Coleoptera, 3 Planipennia, 21 Lepidoptera, 10 Mallophaga, 9 Cimicidae, 8 other Rhynchota, 38 Orthoptera, 121 Ticks, 2 Chelifers, 7 Spiders, 10 Scorpions, and 12 Entozoa ; from British E. Africa and the Tanganyika Territory ; 8 *Tabanus*, 6 other Diptera, 3 Coleoptera, 2 Lepidoptera, 2 Rhynchota, and 2 Orthoptera ; from Southern Nigeria ; 12 Nycteribiidae, and 35 Mallophaga ; from Kamerun ; and 10 Tabanidae, 338 other Diptera, 2 Chalcids, 138 other Hymenoptera, 62 Lepidoptera, 3 Trichoptera, 70 Coleoptera, 57 Rhynchota ; from U.S.A.

Lieut.-Col. W. Rainey, Government Veterinary Officer :—1 Bot-fly ; from Fiji.

Dr. W. Roepke :—50 Lepidoptera ; from Java.

Dr. A. T. Stanton :—79 Culicidae, 1 *Phlebotomus*, 2 *Haematopota*, 4 *Tabanus*, 12 *Stomoxys*, 6 other Diptera, 2 Hymenoptera, and 3 Rhynchota ; from the Federated Malay States.

Mr. Robert Veitch :—84 Diptera, 119 Lepidoptera, 117 Coleoptera, 67 Hymenoptera, 1 slide of Thrips, 25 Rhynchota, and 19 Orthoptera ; from Fiji.

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